ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 184 No. 4777 *LONDON, FRIDAY, SEPTEMBER* 27, 1957 PRICE 2s.

ASSEMBLING A GLANDLESS PUMP

Naimbrie photograph for ENGINEERING

SEPTEMBER 27, 1957 VOL. 184 PAGES 385–416

ENGINEERING

An Illustrated Weekly Journal

Vol. 184 No. 4777 SEPTEMBER 27, 1957

Leading Article
Creative Critics 385

Plain Words 386

Special Article
Food Processing and Canning: Engineering Factors 386

Letters to the Editor
A Sample Without Sir Winston 389

Companies in the News 390

Obituary
Mr. V. A. Patterson, C.B.E. 390

Automobile Engineering
Baby Cars Dominate Frankfürt Motor Show 391

Forthcoming Exhibitions and Conferences 398

Book Reviews
The Problem of Scientific and Technical Manpower in Western Europe, Canada and the United States 402
Mehr Technik—mehr Ingenieure: Der Mangel an Maschinenbau-Ingenieuren 402
Waterhammer Analysis 402

Trade Publications 403

On the Shelf 403

Atomic Review
A Second Draught 412

Notices of Meetings 415

★ ★ ★

Metals and Materials
Tensile Tests on Titanium: Control of Strain Rate 392

Plant and Equipment
Machine for Dust-Free Grit Blasting 396
Oxy-Acetylene Rivet Heating Furnace 397
Spares Packaging 397

Marketing 397

Management
Weekly Survey 399

Research and Development
Fish Sounding Developments 400
Fishing Boats and Gas-Turbines 400
Solar Magnetograph 400
The Experimental Mathematician 401
Above Mach 10 401

Production
Press Tools from Plastics: Epoxide Resins have Many Uses 404

Design
Equivalent Circuits and their Application to Induction Motors 405
Anglo-American Aeronautical Conference 407
Conducting Postage Stamps 408
How Good are Soviet Engineers?: 3—The Soviet Engineer as a Designer 409

Construction
Plans for Future British Power Stations 414

The Human Element 416

★ ★ ★

Published every Friday by Engineering Limited, 35 & 36 Bedford Street, Strand, London, W.C.2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 *months, Inland and Abroad* £5 10s., *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s.* 3*d.*)

CREATIVE CRITICS

EVERY civilised person thinks he has good taste. Even though he may be lacking in creative ability, he knows what he likes when he sees it. Thus we are all critics though few of us are artists. This one-sidedness in our natures leads to difficulties and frustrations in the engineering industries, because in one way or another we are all involved in some aspect of design—whether in producing, researching, selling, advertising, managing or using. We inherit a design, or we are given a design which we must accept whether we like it or not. If anyone is minded to break this vicious circle how does he set about it?

The first move is to spread a feeling of dissatisfaction with the present design. When this feeling has become general at all levels, the time is ripe to steer everyone concerned into their correct positions for co-operative work. The Council of Industrial Design have recently published a booklet on the subject. Called *The Management of Design* (3*s.* 6*d.*, 4*s.* post free) it is a readable report of the Design Congress held in London last year. The Council's interest leans towards consumer goods and is concerned more with purely visual qualities than with technical and functional features. The chosen illustrations of good design are therefore mostly of electric appliances, fabrics and furniture ; but typewriters, calculating machines and the like are some of the quite complicated machines in which the design of appearance has become increasingly important in recent years. The trend is spreading to non-consumer goods.

There is certainly no uniformity in the type of organisation adopted by firms with successful design histories. Some put most of the responsibility on one pair of shoulders —a design director, sometimes with a seat on the board. Others prefer to work by committee, stimulated by the active interest of a director. Some use outside consultant designers; others prefer to keep the responsibility within the firm. The most suitable arrangement depends on the size of the firm, the nature of the products, the capabilities and personalities of the staff and the firm's tradition in design matters. One of the speakers at the Congress put his finger on the central factor when he said: "I believe that the main rôle of the chief executive is to obtain the simultaneous study of questions that have an economic, aesthetic and technical aspect in such a way that they are joined together by a common subordination to the demands of the precise programme." Another speaker said that the first part of the design plan is the immediate programme, and the second part is trying to look ahead five to ten years. The plan ensured that management direction was given to the designers. Feedback from the sales department and customers was reflected in the original management plan. The designers met together as a team periodically to go over this plan, to analyse it and to add their own contributions. The composite plan then became their guide and also the standard by which their performance was judged.

The designer himself can become a problem child unless he is handled carefully. Mr. Leslie Gamage, joint managing director of the General Electric Company, expressed it thus: "In the haphazard way in which the appearance designer is frequently introduced into a company's organisation, antagonisms are certain to be created between the specialist designers and the new boy who, particularly in the technical fields, is seldom able to speak the same language. And if the new boy so much as implies, as I am afraid he sometimes does, that there is no industry or trade too complex for him to master, the specialist's natural suspicion is immediately sharpened." A consultant designer, Mr. Misha Black, also puts much of the onus on the firm by pointing out that when the client could discriminate between a creative and a mediocre solution he exercised so important an influence on the job as to make him almost equal to the designer in determining its final form. The designer's education and background are, of course, of fundamental importance. Often he is an artist with an acquired sense of business and engineering, but he may be an engineering designer who has been given training in appearance design.

If a team or a committee are entrusted with design, their best work is not so much the sum of their contributions as the product of cross-fertilisation of different minds. If, at some stage in their work, a member of the team seems to originate a new and valuable idea, it is not that he has or could have done this unaided, but that the idea was coming to the surface as a result of corporate thinking and he happened to be the first to catch sight of it. The desire for individual credit must therefore be subordinated. And just as there must be ample freedom for new ideas to be ventilated, so there must be positive arrangements for ensuring that design policy is based on the right premises. As Mr. Gamage remarked, strongly held personal opinions are not sufficient and are even dangerous. "If a top executive should think he knows what he wants, let him have his ideas confirmed or contradicted first by market research before he commits himself too far in his designs. And if he is contradicted by market research, let him not dismiss the findings as so much nonsense." We all have to swallow a bitter pill sometimes.

Cover Picture. *The glandless pump makes possible the circulation of fluids in a perfectly closed system as may be required in a nuclear energy plant. The one in the illustration is for handling liquid sodium, and extreme cleanliness is required in its assembly.*

* * *

Plain Words

Recent reports of subliminal advertising are arousing justified indignation. It is disquieting to contemplate the possible effects of a medium of persuasion which can be employed without the people at whom it is directed being conscious of it. A message, a slogan or a trade symbol is flashed on the television or cinema screen for a split second —for so short a time that the viewers don't consciously see it—but the unconscious in us absorbs it like blotting paper, and in due course we choose the product in question in preference to other makes of the same product. Few people can resist the influence of normal advertising techniques; no one, it seems, can resist this method except by refusing to watch all television and film.

But even such a self-imposed ban as this—which would not be difficult for some diehards—may not be a complete safeguard, for surely there are ways and means of flashing a message somewhere, somehow, without the unfortunate subjects being aware of it. The fact that the method is not new is no comfort; it is reported to have been tried out in London over twenty years ago, when experiments were also carried out with subthreshold advertising using sound which was outside the normal audible range.

Who can fill the rôle of guardians of our unconscious? There will doubtless be a call for some form of Government control, but this will take time and may be difficult to institute. There is already available a possible means of control which some of the national newspapers could operate. Special cameras are used for monitoring television programmes, i.e. for taking a film record of programmes in case the newspaper wishes to publish a picture of a particular incident or scene. If the newspapers which use these cameras would arrange to examine the screen in this way, television programmes, at least, would be taken care of. The Press would thereby live up to the tradition it enjoys in all free countries—that of condemning public abuses.

But it would be a mistake to assume too readily that this psychological trick can only be used by subterfuge. The suggestion has been made that it could be used to speed up learning, especially learning things by heart. For if the thing to be learnt is first impressed on the unconscious by repeated flashes—at intervals to be decided by experiment—then it may be possible to shorten appreciably the conscious learning time. It is possible, too, that anything learnt in this way will be more permanently fixed in the mind. If this hope proves to have been justified, then a technique which at first sight appeared to be almost wholly unethical could be turned to good account.

FOOD PROCESSING AND CANNING*

ENGINEERING FACTORS

By J. Hawthorn, B.SC., PH.D., A.R.C.S.T., F.R.I.C.†

Food processing is a much-maligned term and protests of an ill-informed minority against it have received publicity from time to time in the national Press. Let it be said at the outset that the existence of civilisation as we know it is dependent on a continuing supply of food which would not be available without the services of the food processing industry. The earlier civilisations were dependent on the storage of cereal crops to feed large numbers of people congregated on a small area of land. To-day the problem differs only in degree and is illustrated by the necessity of feeding a population of some fifty million people in the United Kingdom, an area of land which in Roman times could support a population of about one million.[1]

The food industry is the largest consumer industry in the country. The Central Statistical Office estimates that in 1955, British housewives spent £4,136 million on food. In the same year the country spent £1,864 million on building and civil engineering projects.[2] Yet as a nation we are complacent about our food supplies, a complacency reflected in the fact that while every University in this country has a Chair of Civil Engineering there is not a Chair in Food Science or Food Technology in any of them.

The object of food processing is simply to handle foodstuffs from the moment of slaughter or harvest to the time of their ultimate consumption in such a way as to give the maximum benefit to the consumer. The food processing industry therefore attempts not only to preserve foods which have to be transported over long distances or stored for prolonged periods, but also to present the finished products as attractively as possible. It is clear that, however nutritionally valuable a food may be, if unattractive it will not be consumed in sufficient quantity to meet the physiological needs of the individual. Since foods are of great chemical and physical complexity, the problems raised by these requirements have received contributions from such diverse disciplines as chemistry, biochemistry, plant and animal physiology, microbiology and physics, and during the past 20 or 30 years the special branch of knowledge co-ordinating these concepts has become increasingly known as Food Science.

Appert working at his home at Massy (Seine et Oise) discovered the principles of food preservation by sterilisation. In his book[3] on the subject they are described as follows:—

(1) A renfermer dans les bouteilles ou bocaux les substances que l'on veut conserver;

(2) A boucher ces différents vases avec la plus grande attention; car, c'est principalement de l'opération du bouchage que dépend le succès;

(3) A soumettre ces substances ainsi renfermées, a l'action de l'eau bouillante d'un bain-marie, pendant plus ou moins de temps, selon leur nature et de la manière que je l'indiquerai pour chaque espèce de comestible;

(4) A retirer les bouteilles du bain-marie au temps prescrit.

The same essential principles are used throughout the canning industry to-day. In 1810 Peter Durand[4] took out a patent for the preservation of food in tinned steel containers instead of Appert's stout glass bottles and about a year later Bryan Donkin, a Fellow of the Royal Society and business associate of John Hall, the founder of the company well-known to-day as J. and E. Hall Limited, adopted the use of steel containers for preserving food on a commercial scale. Donkin, who no doubt was looking for an outlet for the products of the Dartford Iron Works with which both he and Hall were associated, is thus credited with the founding of the canning industry. Perhaps the most striking triumphs of the industry in its early days were contracts to provision the expeditions in search of the American Northwest Passage which were being so actively prosecuted under Captain Sir Edward Parry in the 1820s. By a series of

Fig. 1 Operations involved in closing open-top can.

PRINCIPLES OF FOOD PRESERVATION

The methods devised by the food scientist must be put into practice by the engineer. It is my purpose in this paper to discuss a few of the contributions which engineering has made to food processing, and rather than attempt the description of the many highly ingenious machines which have been designed for specific purposes, I shall seek attention for the techniques which have led to the major developments in the industry. Around the year 1804, Nicholas

* Paper read before Section G of the British Association at Dublin on Monday, September 9, 1957.

† Department of Food Science, Royal College of Science and Technology, Glasgow.

Fig. 2 A fieldsman communicating by radio telephone from field to factory on crop quality.

happy coincidences two of the cans prepared for Parry's expedition of 1824 were preserved in the National Maritime Museum and came to light as a result of investigations carried out principally by the late Sir Jack Drummond. In 1937, the contents of one of these cans was fed to experimental animals who ate eagerly and appeared to enjoy their meal. The early canners believed that the presence of air was the main cause of putrefaction of food and that the success or failure of their process depended on the removal of the last trace of air from the cans. The cans were constructed with a small hole at the top through which the food was filled, and which was subsequently closed at the end of the heating process and while the cans were still hot by means of a cap soldered into place. Modern descendants of these hole-and-cap cans were used for some special purposes as recently as 1929 but they have been almost completely superseded by the open-top can introduced by Max Ams in 1896.[5] The early soldered cans had to be filled by hand, were difficult to clean properly and had to be opened with hammer and chisel. The open-top can not only avoided these difficulties but made mechanisation and consequent large-scale production of cans possible.

CLOSING OPEN-TOP CANS

The method used for closing the open-top can is simple in principle. Fig. 1 shows the operations as carried out on a machine made by the Metal Box Company. The lid is stamped out from sheet plate with a slight curl on its edge, the curl corresponding to a flange made on the can body. By means of suitably arranged rollers the lid is joined to the body by a folded double seam. The seal is completed by a thin layer of rubber latex deposited on the inside of the lid. Seams made in this fashion on accurately-set machines are bacteria-proof, are capable of holding a pressure of up to about 20 lb. per sq. in. and retain their properties under moderate stress. The advantages of the open-top can quickly established themselves and opened the way to mechanised canning lines and continuous production in the canning industry. Nowadays closing machines running at speeds of 360 cans a minute are commonly used in America although British practice favours much slower speeds of up to 180 cans per minute.

High-speed can-closing machines are of little value unless they are fed by high-speed filling machines. Since the very rapid deposition of food into a moving can is necessarily a somewhat violent operation with consequent damage to the food, can-filling machines are designed with large rotating filling heads so that a number of cans are filled almost simultaneously, the food being gently deposited in each can as it travels round the head. These filling and closing machines are linked back to continuous preparation lines and are followed by either batch or continuous sterilising equipment. Production figures of a million cans a week are not uncommon in British canneries, the total number of cans manufactured in this country being about 2,500 million per annum. It is a tribute to the canning industry that in spite of these high production figures the incidence of food poisoning from canned foods is remarkably low.[6]

USE OF STAINLESS STEEL

From the point of view of the designer of all this machinery, special problems have arisen which are almost unique to the industry. Canning factories are inevitably wet places and corrosion problems can be serious, not only from the replacement point of view but from the even more important considerations of hygiene and sanitation. There has thus been a continual demand for new materials of construction and there is no doubt that metallurgy made one of the major contributions to food processing with the introduction of stainless steel. Although austenitic steels were first produced by Hadfield as early as 1882, modern stainless steels trace their ancestry to the work of Brearley and Strauss between 1912 and 1916. So valuable are these steels, especially in their more modern forms, that for many items of food plant they have become an almost automatic choice. With a very few exceptions, mainly in the handling of dilute salt solutions, stainless steel fabrication offers immense advantages. It is more easily cleaned than most other metals and its high resistance to corrosion leaves a smooth polished surface which offers little harbourage for microbial infection, but of late, glass has appeared as a competitor, particularly in pipe-lines, where its transparency gives an immediate indication of its internal cleanliness.

CANNING PEAS

Canning processes are too complex to discuss in detail in a paper of this kind and I propose therefore to consider the canning of a single product to illustrate the problems involved. The largest single canned pack produced in this country is peas, and I shall outline the sequence of operations involved in the canning of peas in a modern factory, viz., the Sheffield factory of Batchelor's Peas, to illustrate the progress that the industry has made since the days of Appert. The varieties of peas which are suitable for canning are limited, and the canner's work starts in winter-time with the preparation of farmers' contracts to grow a given variety of crop. These contracts offer the farmer a fixed price for his produce before he has sown the seed, and they usually carry a bonus clause giving a higher price subject to the crop conforming to certain quality standards. Since such contracts guarantee a fixed price to the farmer irrespective of the market price ruling at the time of harvesting, the farmer can be sure of a fair return for his work in a glut season and the canner is sure of at least some of his peas at an economic price in a poor season. Since very large acreages are involved, these contracts introduce a stable note in the agriculture of the areas where they are applied, and the point is worth emphasis in that it illustrates the importance of food processing in economically absorbing agricultural surplus. In addition, some processing firms employ agricultural advisers to assist the farmer in the preparation of his land for the crop and the resulting increase in land productivity benefits not only the farmer and the canner, but the community as a whole.

When the crop is mature it is usually harvested by a reaper (Fig. 3) which cuts the whole plant at ground level. The resulting tangled mass of pea-vines with their attached pods is shipped to the cannery by lorry, usually reaching it within a few hours of harvesting. The crop is fed from the lorry into a vining machine which removes the peas from the pod and separates the plant debris in a single operation. One of these machines, made by Messrs. Mather and Platt Limited, is illustrated in Fig. 4. The machine consists essentially of a series of beaters which crack the pods open and the loosened peas are

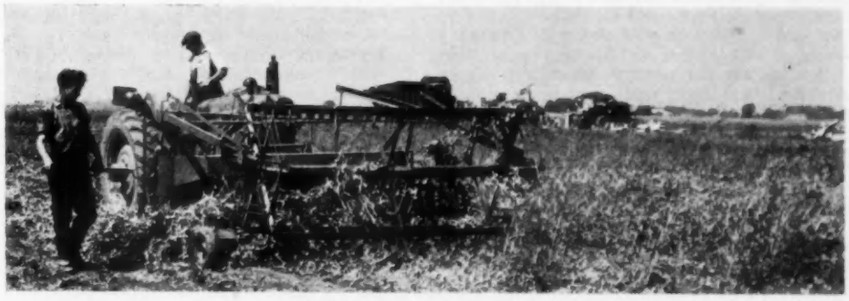


Fig. 3 Harvesting peas.

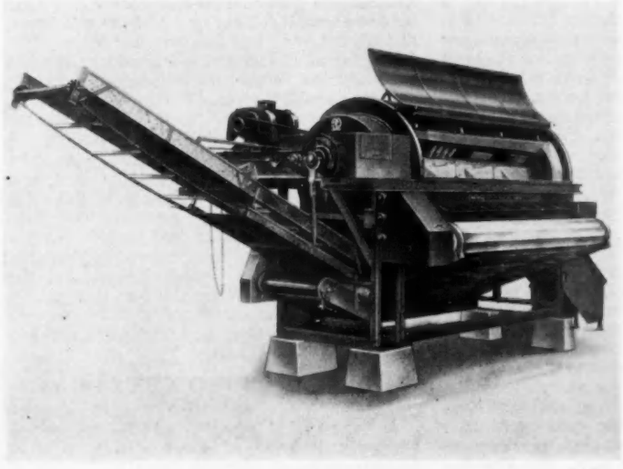


Fig. 4 Pea vining machine.

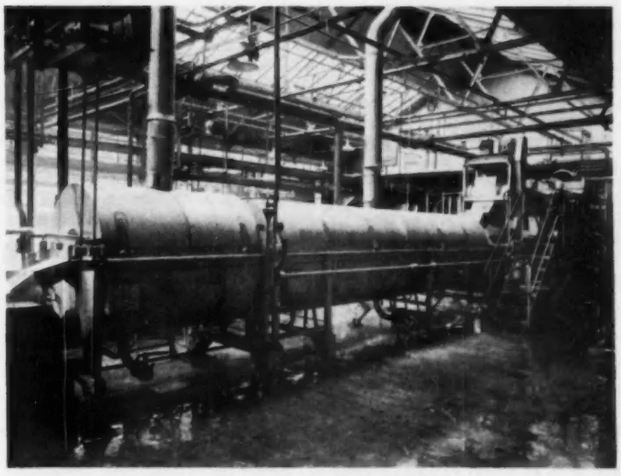


Fig. 5 Pea blancher and washer.

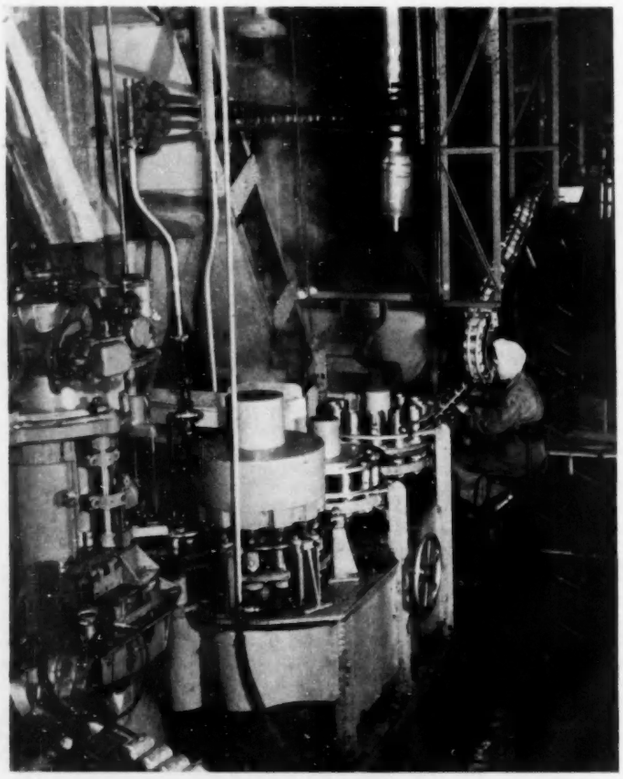


Fig. 6 High-speed filling and closing machine.

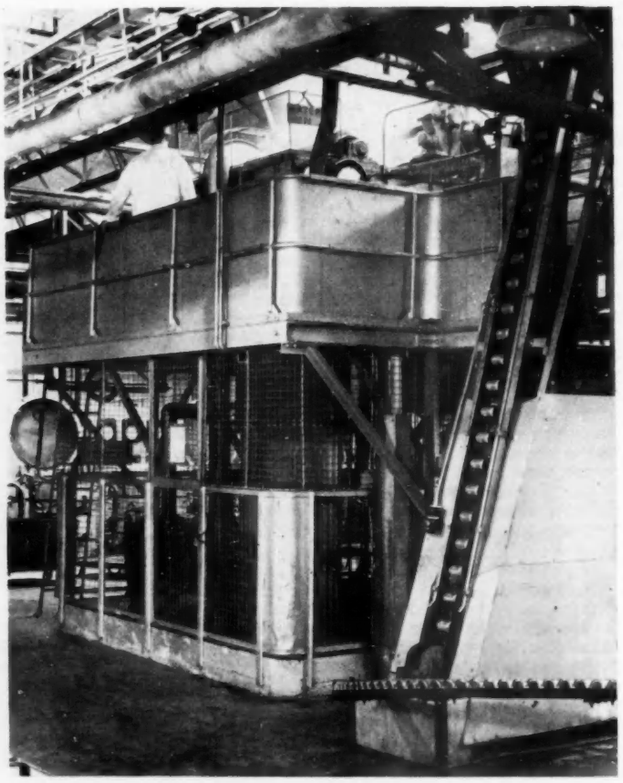


Fig. 7 Carvallo high-speed continuous pressure steriliser.

then separated from the bulk of the plant debris by screens. A combine pea-harvester has now been in operation in America for several years which cuts the plants and separates the peas on the field.[9] The peas may now pass through a series of size-grading or flotation separations depending on the product which the canner requires. In these processes, contaminating trash in the form of weed-seeds, small stones, grit and small fragments of pea vine are removed, and the peas are size-graded. Since the war there has been also a tendency to grade peas by specific gravity, the less dense and more succulent peas fetching a higher price.

After these preparatory processes, the peas must be blanched by immersing them in near boiling water for periods of from two to ten minutes. Fig. 5 shows the plant in which this operation is carried out. Blanching serves a number of purposes. It removes oxygen and other gases trapped in the plant tissue, it helps to soften the skins of the peas and it gives a final wash thus removing any still-adhering traces of grit or mud. After blanching, the peas are cooled in water sprays, passed over a final inspection belt and fed to filling machines through which the empty cans pass at rates of from about 60 to 200 cans per minute. These machines, one of which is illustrated in Fig. 6, automatically fill the correct weight into the can and it is now possible to use a radioactive monitor to correct any tendency for the measuring pattern of the machine to vary throughout the course of a day's run. The peas must now be covered with a suitable cooking liquid. A dilute solution of salt and sugar is used for this purpose along with a little harmless colouring matter and a trace of mint essence. Colouring is added because during the subsequent sterilising process, chlorophyll degrades to a khaki-yellow pigment known as pheophytin which looks rather insipid.

The covering brine is usually filled hot and the cans are subsequently "exhausted"; that is, they are passed through a steam-heated chest or tunnel to raise the temperature of the can contents to about 150 to 170 deg. F. before the lids are sealed on. Still moving continuously, they pass to the closing machine before sterilisation.

The object of the sterilisation process is, of course, to kill all contaminating micro-organisms, and this requirement is normally met by heating under steam pressure to a temperature of 240 deg. F. and holding at that temperature for a time which varies with the product. Sterilising may be carried out in batch retorts each capable of holding about half a ton of food or in continuous cookers of which there are a number of designs. Continuous sterilisers, one of which is shown in Fig. 7, must be provided with transfer valves to allow the cans to enter the high-pressure region. Much consideration has been given to the design of such valves but as a result of the inevitable mechanical wear and steam losses to which they give rise, there has been great interest in recent years in pressure cookers in which the can enters the sterilising zone through a 30 to 50 ft. vertical column of water, the barometric head providing a liquid pressure seal. Since continuous cookers keep the cans in constant movement throughout their sterilisation period, the shaking of the can contents increases the rate of heat transfer over that obtained in stationary retorts. On the other hand, agitation may often cause a breakdown of the delicate plant tissue with the subsequent formation of a mushy product. Thus many canners still prefer to use the rather laborious batch retorts with the object of achieving a better quality product.

IMPORTANCE OF CLEANLINESS

I wish to make two points following from the description of this process. The first of these is that in the quite complex machines involved in a cannery, accumulation of vegetable debris in dead spots in machines can happen only too easily and the utmost attention to designs which eliminate such dead spots is required on the part of the engineer. Moreover, designers have recently shown a tendency to give machines a streamlined appearance by clothing them in gracefully contoured sheet metal and claiming that the resulting design represents a high standard of hygiene. This by no means follows. The enclosure of supporting struts often gives rise to an inaccessible portion within the machine which cannot be cleaned without stripping it down. By attention to these simple points the standards of hygiene in the food industry could be markedly improved. A special warning to designers against the use of H-section and steel angle is required for many applications; especially under wet conditions, welded tube is to be preferred.

I do not wish to infer from the foregoing that standards of hygiene in processing factories are unsatisfactory. A clean factory means smaller processing losses and lower costs in the long term, and this factor contributes powerfully to good standards in most factories. It is well, however, to maintain a sense of proportion in relation to standards of cleanliness. Our ancestors lived on food prepared under conditions we should deem disgusting and yet managed to survive well enough. Every year we bake several million tons of flour into bread and almost every loaf can be shown to contain fragments of insects and a few odd hairs from rats and mice. We eat our bread quite cheerfully and are no whit the worse. The real dangers of unhygienically prepared food arise from the possibility of an outbreak of food poisoning, the most important types of which are produced by micro-organisms growing within the food, and the offending food may often look and taste perfectly normal. Every engineer designing food machinery is well advised to devote a few hours to the study of food poisoning (there are one or two excellent standard works on the subject) and to reflect on the fact that a little more care in the design of a machine may prevent an outbreak of this unpleasant and too often fatal type of illness.

REFRIGERATION AND QUICK-FROZEN FOODS

A survey of this sort would be incomplete without at least a brief reference to the benefits brought to the food industry by the invention of mechanical refrigeration processes. Refriger-

ators and cold stores are now so much a part of everyday life that it is hard to believe that the first practical refrigerating machine was made by Linde as recently as 1875. It is true that natural ice had previously been used to extend the storage life of foodstuffs (there are records of the Romans having ice brought from the Italian Alps to chill their wines in classical times), but it is difficult in the space of a few minutes to give any idea of the revolution in food handling, and indeed in dietary patterns, which has been brought about by Linde's invention. One of the earliest applications of Linde's machine was the opening up of the overseas meat markets which contribute greatly to our material well-being.

However, the full possibilities of food freezing were not appreciated until 1929. In that year, Clarence Birdseye carried out some investigations on the effect of freezing rates on food quality and discovered that if freezing were carried out very rapidly a product of high quality could be obtained.[10] By 1931 he had floated a company to process and market these quick-frozen foods. His products were an immediate success, and his name is recalled in the brand name of the company he founded. Birdseye realised at the outset that food processed by his method would be somewhat more expensive than canned foods and determined to base the policy of his company on high quality at a little extra cost. The early demand was so great that in spite of serious distribution problems the industry expanded very rapidly. The Birdseye process was introduced to Great Britain just before the outbreak of war in 1939, and expanded slowly but steadily after 1945 until about 1952. Since then, its growth has been very rapid, and quick-frozen foods are undoubtedly here to stay.

So much for the past history of food processing in which the part played by the engineer has often been fortuitous. In the future, more engineers will be required for the development work ahead. All existing methods of food processing are subject to a number of limitations. The sterilisation process means that canned products are always cooked, and many foods, such as lettuce and fruits, are preferred raw. Again, since the cooking process must always be sufficient to destroy any micro-organisms which may be present, it is often necessary to overcook canned products to ensure that they are sterile. Canned potatoes, for example, have never been a great success, except for emergency use, because the sterilising process overcooks them. Moreover, some foods depend on the method of cooking used for their flavour and texture, and it is not easy to can a prime steak and produce a flavour and texture similar to that obtained by grilling it. Again, canned bacon is insipid stuff when fried and tends to fall to pieces in the frying pan. Some of these limitations can be met by quick-freezing, but frozen fruits, while retaining the flavour of the fresh fruit, lose crispness and bloom on thawing. As a result of these and many similar considerations, the food-processing industry is continually seeking new methods of preservation, either with a view to extending the shelf-life of a product or to its permanent preservation.

STERILISATION BY RADIATION

In the past few years the possibilities of using radiations of various sorts to sterilise foods have been given extensive consideration, expecially in the United States, and more recently in this country. Four main types of radiation are known to destroy micro-organisms. The first of these is ultra-violet light, the penetrating power of which is so low that it is only of very limited applicability. X-rays have excellent properties of penetration, but commercial X-ray machines operate at such low efficiencies as to be valueless for this purpose. High-energy electron beams obtainable from machines such as the Van de Graaf accelerator, the capacitron or the linear accelerator offer economic possibilities in spite of high capital cost. The limit of penetration of such radiations is of the order of one to three centimetres, and in turn this limits the size of the food package which can be treated. It is true that by increasing the applied voltage the penetration can be improved but a limit is set to this by the danger of inducing radioactivity in the food. At the moment, the most attractive possibility is to use the gamma-radiation from radioactive "waste" materials from nuclear reactors.

The sterilising power of these radiations depends on their ability to ionise the material through which they pass. Ionisation within the food spoilage micro-organisms is minute, but sufficient to upset the delicate chemistry of the bacterial cell, and the organism dies. The great advantage of this method is that the total amount of energy imparted to the foodstuff is small. In order to sterilise a piece of meat by heat its temperature must normally be raised through at least 80 deg. C. Using electron beams, the same piece of meat may be completely sterilised with the absorption of energy equivalent to the raising of its temperature by a maximum of four degrees. Provided that the material is first placed inside a bacteria-proof container, bacterial attack on the meat can be completely inhibited.

Unfortunately, other complications arise. The ionisation which kills the micro-organisms also brings about chemical changes in the food; irradiated butter may be bleached as white as lard. Milk and meat develop taints, and off-flavours of one kind and another arise in most foods. By careful control of temperature and by removal of oxygen from the food before irradiation, some of these taints can be reduced or in a few cases eliminated completely, but even then the difficulties are not at an end. In addition to spoilage by bacterial action, foods may spoil by the intervention of enzymes. These substances are present in all biological materials and while their action is much slower than that of bacteria, during prolonged storage it becomes a serious problem. Enzymes are destroyed by heat and are therefore eliminated in canned foods.

Irradiation also destroys them but only if massive doses are used, and the use of such high doses brings serious off-flavour troubles in its wake. The table illustrates this effect in general terms. There are varying reports of lethal dosages in the literature and the figures below are to be regarded as representative and not absolute, but they illustrate the trend of higher doses being required for the destruction of smaller entities. Thus, where enzyme activity is likely to cause spoilage, the enzymes must be destroyed by heat before irradiation.

TABLE I.—*Destructive Effects of Irradiation*

Subject	Representative Lethal Dose (rads.)
Man and mammals	500
Insects	50,000
Bacteria	500,000
Enzymes	5,000,000

From this brief outline it can be seen that many problems remain before radiation sterilisation becomes an economic process of wide commercial application. In the past two years increasing attention has been paid to the use of radioactive waste materials for industrial purposes and their use in the food industry offers attractive possibilities. The first applications are likely to be aimed at increasing the storage life of packaged foods which can be achieved by the application of small doses producing almost no ill-effects on the food, and the technical knowledge is already available to do this. On the other hand, before radiation sterilisation can be applied commercially every care must be taken to ensure that the treated food is harmless to the consumer. Evidence pointing to this is gradually becoming available, but because of the chemical complexity of foods and the difficulties in deciding on what constitute harmful effects, some time must elapse before final conclusions can be drawn.

CONCLUSIONS

In summing up, it may be said that although food processing has received scientific attention in the past there is still a great need for intensive work in this field. In the history of the subject, some at least of the major developments have come from outside the industry and in these the engineer has played an important part. It is certain that he will have an increasing part to play in the future and it will be necessary for engineers entering this field to become familiar with the outlines of the chemical and micro-biological problems facing the food scientist. Only by close co-operation between the two can the problems be solved to the best advantage of the community at large. In his Appert Award Address last year Professor B. E. Proctor discussed the future of food processing. He concluded, "Certainly, Nicolas Appert, whom we honour to-day, would be both surprised and gratified to count the lives, perhaps millions of lives, which have been literally saved by the process of heat treatment for preservation in which he played so great a part a century and a half ago. Much has been done by others in the ensuing time towards improving these methods. Such efforts should never cease, as improvements are always possible."[11]

BIBLIOGRAPHY

[1] Churchill, W. S., *A History of the English-Speaking Peoples*, 2nd ed., vol. I, page 30, 1956 (Cassell, London.)

[2] Annual Abstract of Statistics, Tables 188 and 284, 1956 (London: H.M.S.O.).

[3] Appert, N., "L'art de conserver pendant plusieurs années toutes les substances animales et vegetables." 1810. (Patris et Cie, Paris.)

[4] Durand, P., British Patent No. 3,372 (1810).

[5] Ams, M., British Patent No. 29,286 (1896).

[6] *Food Canning*, page 48, 1952. (Anglo-American Council on Productivity, London.)

[7] *Meat Packaging and Processing*, page 22, 1951. (Anglo-American Council on Productivity, London.)

[8] Dewberry, E. B., *Food Poisoning*, 2nd ed., page 74, 1947. (Leonard Hill, London.)

[9] *Food Canning*, page 28, 1952. (Anglo-American Council on Productivity, London.)

[10] Birdseye, C., *Ind. Eng. Chem.*, vol. 21, page 414, 1929.

[11] Proctor, B. E., *Food Technology*, vol. 10, page 393, 1956.

* * *

Letters to the Editor

A SAMPLE WITH SIR WINSTON

SIR, I am flattered by the attention ENGINEERING has paid to a paper of mine—"Some Recent Studies of the Effects of Age on Intellectual Processes"—given at the recent meeting of the British Association in Dublin (Human Element note, ENGINEERING, September 13, page 352), but I feel that your comment showed that an important point in my paper had been missed and your readers may have been misled. Far from being concerned with the "average," Lehman's work dealt with the "top people"—the Edisons, Colts, Curies, Davys, Galileos and Joules—as well as with the lesser mortals who have managed to make valuable contributions to human intellectual achievement. Even my own work dealt with a sample of subjects with superior intelligence: in fact, not a single case referred to in my paper had what would be called only average intelligence. Hence, your comment would have been more logical had it said that these results " . . . are relevant to the outstanding person but not to the average individual," which is exactly the opposite of what it did say!

As for your headline "A Sample Without Sir Winston," I can only recommend you to read chapter 11 of Lehman's book *Age and Achievement*, or, better still, all 20 chapters, and the puzzle will begin to sort itself out.

Yours sincerely,

D. B. BROMLEY.

Department of Psychology,
University of Liverpool,
7 Abercromby-square,
Liverpool, 7.
September 17, 1957.

Companies in the News

Trends of Profit

The chairman of a medium-size engineering group, John Folkes (Lye Forge) Limited, told his shareholders that: "taking the group as a whole, I think that our parent company will not do quite as well as last year: our motor trade subsidiary will do better than last year; our two subsidiaries operating in the light engineering field will also increase their profits. Moreover there will be the profitable addition of the new subsidiary company just acquired." This is typical of the go-ahead engineering company. Mr. John Folkes spoke after the engineering pay awards had been made; he said this after a review of activities during the year ending March 31. The major event since Mr. Folkes' optimistic forecast is the unfolding of the Chancellor's policy to contain inflation and strengthen the £. The Bank rate at 7 per cent., and the restrictions on lending which go with it, will obviously hit consumption. Hire-purchase facilities will be harder to get and the demand, therefore, for some consumer goods will fall. Some of the industries Mr. Folkes' companies supply will not do so well. Cars and electrical household appliances are obvious targets of the new restrictions.

The *Financial Times* recent analysis of the profit figures of 2,485 companies for the first eight months of the current year shows that earnings on equity are 1·9 per cent. down on the previous year, whereas a year ago they were up by nearly 14 per cent. During the past three years trading profits have increased by 12·6, 10·1 and 4·6 per cent. (first eight months of 1955, 1956 and 1957 respectively). Margins this year are down, largely because overheads and labour costs have increased; raw material prices were generally lower. It is therefore unlikely that higher dividends will be paid out and capital will therefore tend to become scarcer. The inability of British industry to pay a reasonable return on investment is no small factor in the flight from the pound Mr. Thorneycroft is trying to arrest.

★ ★ ★

Changing Direction

To recognise a mistake in time and make amends is the gift of very few. Errors of judgment are never easy to admit, particularly on the part of men in the public eye. Also there is always the hope that "everything will turn out all right in the end."

Imperial Chemical Industries offer a good example of an error recognised and action taken to put it right. In their last annual review, it was recognised that the Ardil fibre project was not going well; last week I.C.I. announced that it would be discontinued. All technical staff have accepted alternative employment in the company, either on Terylene research and development work at Harrogate or Fleetwood or on the supervisory side of the Terylene plant at Wilton. Terylene is going so well that I.C.I. have decided to build a new plant costing £20 million, with a capacity of 20 million lb. of Terylene a year.

Another example of changing direction is the closure by Pilkington Brothers of the group's subsidiary manufacturing plastics components at Ashdowns. The plant's products were mainly components for the motor trade, domestic appliance, radio and electronics industries, as well as glass fibre laminates from material supplied by Fibreglass, another member of the Pilkington Group. As in the case of I.C.I., every effort will be made to find other employment for the 700 employees involved. The company's directors consider that long-term prospects "are not sufficient to justify the further substantial investment which would be necessary" and that greater benefit to the group would result from the use of these resources in their "main business of glass making." This may be the beginning, in a period of greater competition and acute capital shortage, of a pruning of activities by several large groups in industry on a basis of long-term prospects.

★ ★ ★

Motors in Overdrive?

Motor-vehicle manufacturers and their suppliers have had a very good summer, culminating in Britain recovering her lead over Germany as the world's largest exporter of motor vehicles. The results for the past year will not, however, be good since they will reflect the fall in activity of the 1956 winter and summer. Kirkstall Forge and Engineering, who supply large quantities to the motor-vehicle industry, experienced a typical setback, profits for the year ending June 30 being reduced to £181,000 from £240,000 the previous year. Their chairman, Mr. R. F. Butler, complained that credit restrictions in countries other than Britain had reduced the demand for commercial vehicles (in which they are particularly interested) and that competition for the remainder had therefore become more intense. "Although," he said, "the immediate future is uncertain," the directors are confident that "in the longer view there will be an increasing demand for our products."

The improvement in trade which took place at home as well as in overseas markets during the past six months was commented upon by Mr. Allen L. Stock, chairman of Lodge Plugs. Although he anticipated that profits "must be seriously eroded by the increase in labour and material costs over which private industry has little control"—he expressed confidence in the future and considered prospects for the current financial year "more favourable as regards turnover." Sir Graham Cunningham, chairman of the Triplex Group chose the elusiveness of money as the central theme in his annual report and spoke of the increasing need for capital to run an expanding business. He gave an example of an extension to one of their Midlands factories scheduled to cost £65,000 in buildings, £55,000 in plant and machinery, £62,500 for raw materials, work in progress and finished stocks, £62,500 to finance debtors and £10,000 in cash—in all £250,000 to finance a turnover of £300,000. On the question of debtors Sir Graham said "experience shows that our customers (good fellows though they are) take on average two and a half months to pay our bills."

★ ★ ★

Oil Transport and Marketing

The recent announcement by British Petroleum that 20 of their largest tankers have been routed round the Cape of Good Hope to avoid some being laid up suggests the oil industry has far from recovered from the effects of the Suez crisis. The resumption of the ascending trend of demand anticipated is being delayed longer than had been expected. To route the bigger ships round the Cape will cost less than having the ships laid up.

The level of oil consumption in the United Kingdom has none-the-less risen sharply since the re-opening of the Suez Canal and is now higher than this time last year. The switch from coal to oil in industry is picking up again after a period of some months during which many schemes were shelved. Consumption in the second quarter of the year was 2·2 per cent. lower, however, than in the corresponding period of last year. It will take some time for the rate of increase operating prior to the closure of the Canal to be resumed. That it will be resumed does not appear to be doubted by those with the most intimate knowledge of marketing oil products. Sir Henry Wilson Smith, chairman of the Powell Duffryn group of companies, has announced to the group's shareholders that their subsidiary, Cory Brothers, are also extending oil-storage capacity on a large scale. Stevinson Hardy and Company suffered much more from the effects of the Suez crisis. In the second half of their financial year (to the end of April) sales dropped and later prices fell. Earnings were over 6 per cent. down to 20·6 per cent. None-the-less the group has continued to expand and are negotiating to acquire increased storage facilities.

All in all, it is obvious that all is not yet well with the Middle East and users lack the confidence in the continuity of supplies. Storage will help, but at present those who can delay conversions will do so.

★ ★ ★

Seven Per Cent.

Time alone will tell if the shock tactics used by the Chancellor of the Exchequer in raising the Bank rate from 5 to 7 per cent. last week will be justified. Meanwhile it is apparent that the gesture is intended to have as serious consequences to the United Kingdom economy as it is at the meeting of the directors of the World Bank this week at Washington. The move, as announced by the Government, was explained as an attack on speculation in the £. It is clearly intended to go a great deal beyond this first and most important objective.

There is to be a slowing down in the rate of investment and the immediate targets are capital expenditure by nationalised industries and investment by private industries out of bank advances. It seems likely, however, that the brake on investment is going to operate on industry as a whole.

It seem likely that there will be some order of priority so far as capital investment is concerned. Public investment is running at about £1,500 million a year at present and it may well be the target to contain public investment at this level. At the moment the main candidates for a delay in their programmes are clearly the roads, railway modernisation and nuclear power. The public's expenditure is likely to be affected by less attractive hire-purchase terms, but there is no likelihood of an immediate effect on the public's consumption in general. This is an attack in the first place on investment and it will be no more welcome to the engineering industry for that. The danger in the longer run is that resources prevented from being used on investment may be used for consumption, an outcome which would stimulate and not contain inflation.

★ ★ ★

Obituary

MR. V. A. PATTERSON, C.B.E.

It is with regret that we record the death of Mr. Victor Alexander Patterson, which occurred in London on September 13. Mr. Patterson, who was deputy chairman and managing director of J. and E. Hall Limited, Dartford, Kent, was an Ulsterman by birth and seventy years of age. After receiving his general education at Oundle School he entered the works at Bedford of W. H. Allen, Sons and Company, Limited, as an engineering pupil at the age of 17. Soon after completing his apprenticeship, Mr. Patterson began his life-long association with J. and E. Hall Limited, which association was destined to extend over 46 years. In 1911, at the age of 24, he was appointed an assistant works manager of the firm and was promoted to the position of manager of the refrigeration department in 1913. During the war the company built heavy motor lorries and Mr. Patterson assisted in their increased production. Meanwhile, he continued to manage the refrigeration department and, after the conclusion of hostilities, devoted his whole attention to the development of refrigeration machinery of all types.

Mr. Patterson was elected works director in 1925 and became deputy chairman and managing director in 1949. He was created a C.B.E. in the 1955 New Year Honours List and, quite recently, was made a Deputy Lieutenant for the County of Kent. For many years he had devoted much of his time to the activities of the Engineering and Allied Employers' National Federation.

Automobile Engineering

BABY CARS DOMINATE FRANKFÜRT MOTOR SHOW

By Gordon Wilkins

A whole flock of new baby cars is the outstanding feature of the Frankfürt motor show which opened last Thursday. The success of Lloyd and Goggomobil in bringing low-cost motoring within reach of German workers who are enjoying steadily rising living standards has brought in the big industrial interests to exploit a market whose total extent is still a matter of conjecture. Some observers believe that saturation is already in sight for baby cars which are sub-standard in size and performance, and it is at least fairly certain that a good deal of money and effort will have been lost by the time the survivors emerge from the period of acute competition ahead.

The Zundapp and the improved Lloyd have already been described in ENGINEERING (issue of August 30, page 286) and they have the great advantage that they are already in production, whereas some of the new models exist as prototypes only and may not be on the market for six months or more. Both these manufacturers buy their large pressings out, but can produce small pressings themselves.

Also available for early delivery at a favourable price, is the B.M.W. 600, a small four-wheeled four-seater car developed from the two-seater Isetta, which B.M.W. have been building under licence for some time. An Isetta-style front door gives easy access to the front two seats, and a single side door on the right side admits to the rear seats. The power unit is a flat twin air-cooled o.h.v. engine of 583 c.c., following the company's motor-cycle practice, but with ducted cooling by fan, and deliberately de-rated to 20 b.h.p., partly in the interests of durability and flexibility, but also because German insurance premiums rise sharply for vehicles with more than 20 b.h.p. It is quiet and smooth-running, and has a four-speed fully synchronised gearbox. There is a separate chassis of square section tube, whereas most of the newcomers utilise unit body-chassis construction (Zundapp, N.S.U., Goggomobil). Front suspension is of the Dubonnet type, with trailing arms and coil springs; rear suspension is independent by single trailing wishbones and coil springs, which introduces a second universal joint into each of the drive shafts.

The most remarkable technical *volte-face* has been executed by Goggomobil, who have turned from a rear-engined car with parallel twin two-stroke unit, to a front-engined front-drive car with flat twin four-stroke power unit. It is the work of a former B.M.W. designer, and externally the engine bears a certain resemblance to B.M.W. power units. The engine produces 25 b.h.p. from 586 c.c. and drives through a four-speed gearbox without synchromesh. Suspension is by wishbones at the front with coil springs, and single wishbones arranged as swing axles with coil springs at the rear. The car has a full wrap-round windscreen, and an exceptionally large luggage locker at the rear. However, it exists only in prototype form, and will not be on the market before next June.

After some years concentrating on their fast but fairly high-priced three-cylinder two-stroke cars, D.K.W. have returned to the economy market with a handsome small car in the Volkswagen price range. It has a two-cylinder two-stroke engine of 660 c.c. developing 30 b.h.p. at 4,200 r.p.m., which makes it the most powerful of the new crop, and conforms with traditional D.K.W. design in having water cooling, front engine and front-wheel drive. Transmission is through a four-speed gearbox with the top three synchronised. The bodywork, remarkably large for the power, is a four-seater two-door saloon very similar to the Ford Anglia in outline, and suspension is by torsion bars.

The Auto-Union have also extended their range into a higher performance class by producing the Auto-Union 1000, using the D.K.W. chassis with a new overbored three-cylinder engine of 980 c.c. In the two-door saloon, with 7·25 : 1 compression, it gives 44 b.h.p., but it also figures in attractive new convertible and two-seater coupé models, known as the Auto-Union 1000 coupé and roadster, and with 8 : 1 compression gives 50 b.h.p. installed. These two models typify a marked trend in German production this year; the comfortable sporting coupé, with permanent or folding weather protection and winding windows, and good luggage space.

The Karmann Khia Volkswagen coupé, which has shown the way, is now available as a convertible, as is also the Borgward de luxe two-seater, and another addition to the ranks is a two-seater coupé version of the Goliath with flat-four 1,500 c.c. front engine.

Apart from the Mercedes range, described in ENGINEERING (August 30, page 286), there are two important innovations in the popular family car field; the Opel Olympia Rekord, and the Ford Taunus 17M—one, by the General Motors subsidiary, approximately equivalent to the Vauxhall Victor, the other competitive in price with the Ford Consul.

Long experience with unit body-chassis production has enabled the Opel designers to produce a car which is longer, and wider, with much increased space for passengers and luggage, and with increased structural stiffness, at no significant increase in weight, despite a large increase in glass area. The 45 b.h.p. 1,500 c.c. four-cylinder power unit is unchanged save for better low-speed performance, but the gearbox now has synchromesh on all three speeds. The Ford is a bright modern design, conforming with the international Ford outline, and powered by a four-cylinder short stroke 1,698 c.c. pushrod engine developing 60 b.h.p. at 4,250 r.p.m. It has a three-speed fully synchronised gearbox with steering column shift. General mechanical design conforms with Ford practice elsewhere, including the use of the Macpherson pillar-type front suspension.

B.M.W. 600.

New Volkswagen saloon.

Porsche 1600.

N.S.U. Prince.

Opel Olympia Rekord.

Ford Taunus 17M.

Metals and Materials

TENSILE TESTS ON TITANIUM

CONTROL OF STRAIN RATE

By R. J. Parker, A.M.I.MECH.E.*

In the present investigation tensile tests have been carried out on two titanium-base materials using rates of strain varying from about 2 × 10^{-4} to about 1 in. per in. per min. Proof-stress, tensile-strength and elongation values are rather more affected by speed of testing than the corresponding properties of several steels, copper, brass and Duralumin. In the interests of reproducibility therefore, tensile tests on titanium-base materials should be carried out using strain rates which fall within a fairly confined range, and specifications are in existence which define acceptable limits.

The problem of ensuring that testing always conforms to these requirements has been solved by deriving a theoretical relationship between strain rate and speed of testing, material ductility and specimen geometry. This relationship has been confirmed experimentally for copper, brass, aluminium and mild steel, and then used to define suitable testing conditions for titanium-base materials. The use of a variable-speed testing machine is advocated, and to put the recommendations into practice effectively a novel pacing instrument has been developed and is described.

Published literature contains ample evidence of the attention which has been directed to determining the effect of speed of testing on the room-temperature tensile properties of established metals—see, for example, Jones and Moore[1], Moore[2], and Walker[3]. These investigations were carried out at reasonably normal testing speeds, i.e., they did not involve high-speed or impact-tension conditions, and were concerned with several steels and various copper, aluminium and magnesium-base alloys. More recently, work of this nature has been carried out on titanium-base materials, for instance, by Republic Steel Corporation[4], Kotfila and Erbin[5], Rosi and Perkins[6] and Kondo and Suzuki.[7]

The first section of the present article also deals with this type of investigation, being concerned with the influence of speed of testing on the room-temperature tensile properties of two titanium-base materials made in sheet and rod form by the Metals Division of I.C.I. Limited. In the second part, testing conditions suitable for the determination of tensile properties at standardised rates of straining are defined—particular reference being made to titanium and its alloys—while the third section indicates how these conditions can be obtained in practice.

* Research Department, Imperial Chemical Industries Ltd., Metals Division, Kynoch Works, Witton, Birmingham, 6.

[1] These numbers relate to a list of references given at the end of the article.

PART I—TENSILE TESTS

Materials.—The influence of testing speed on room-temperature tensile properties was determined for two titanium-base materials made by the Metals Division of I.C.I. Limited, namely commercially-pure titanium, and an alloy of titanium containing aluminium and manganese. The actual chemical compositions of these materials are recorded in Table I.

TABLE I.—*Composition of Materials Tested*

Element	Commercially-pure titanium	Titanium-aluminium-manganese alloy
	Per cent.	Per cent.
Aluminium ..	—	1·42
Manganese ..	—	1·51
Carbon	0·047	0·12
Iron	0·03	0·07
Nitrogen ..	0·015	0·004
Hydrogen ..	0·005	0·014
Titanium ..	Remainder	Remainder

The commercially-pure metal consisted of 0·09 in. thick sheet, while the titanium alloy was in the form of $\frac{7}{8}$ in. diameter bar, both materials having been annealed at a temperature of 700 deg. C. Tensile specimens conformed to the requirements of B.S.18; type A test pieces were machined from the sheet material and standard 0·424 in. diameter specimens from the bar.

Tensile Tests.—Two series of tests were carried out on each material, the first series being to determine the influence of testing speed on proof-stress values, the second being concerned with tensile strength and elongation values. A hydraulically operated 15 ton universal testing machine was employed for this work and, in the first investigation, 0·1 per cent., 0·2 per cent. and 0·5 per cent. proof-stress values were determined using various settings of the control valve, these settings being such that the shortest test period was about 1 minute and the longest approximately half an hour. At the beginning of each test, the control valve was opened a suitable amount as dictated by trial experiments, and was not readjusted during the test period. As soon as the load-indicating pointer on the testing machine began to move, a stop watch was started, and, at appropriate levels of applied load, simultaneous values of time, load and extension were noted. The results obtained are recorded in Table II and Fig. 1 for the commercially-pure titanium, and in Table III and Fig. 2 for the titanium-aluminium-manganese alloy. The recorded average strain-rate values were obtained by dividing the specimen extension by the gauge length (2 in.) and by the time taken to extend the test piece by the amount under consideration. During the second part of the work, test pieces were broken in periods of time ranging from less than half a minute to about half an hour, the control valve setting employed in any one particular test being maintained constant until the specimen fractured.

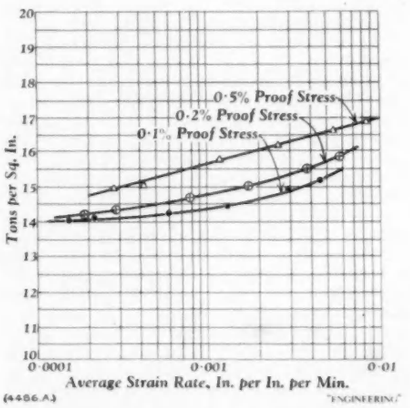


Fig. 1 Influence of strain rate on the proof stress of annealed commercially-pure titanium.

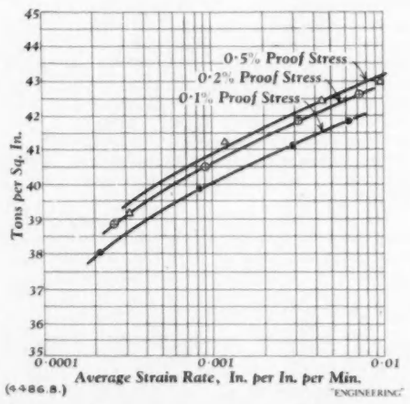


Fig. 2 Influence of strain rate on the proof stress of annealed titanium-aluminium-manganese alloy.

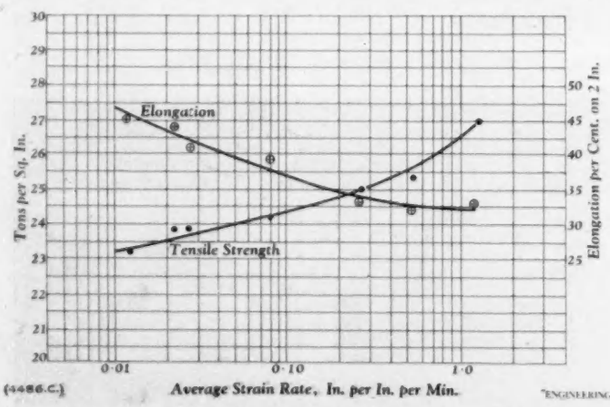


Fig. 3 Influence of strain rate on the tensile strength and elongation of annealed commercially-pure titanium.

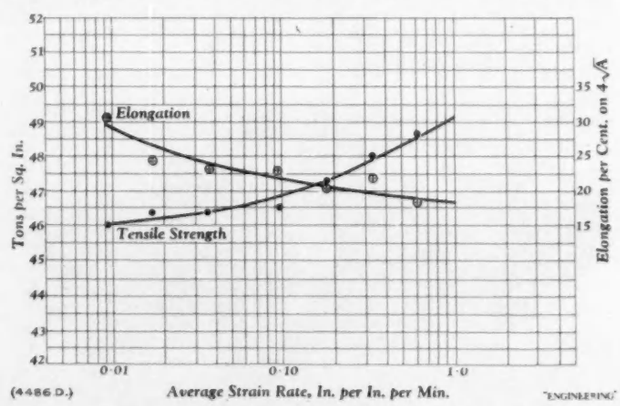


Fig. 4 Influence of strain rate on the tensile strength and elongation of annealed titanium-aluminium-manganese alloy.

TABLE II.—*Influence of Speed of Testing on Proof Stress of Annealed Commercially-Pure Titanium Sheet.*

Test No.	0·1 per cent. proof stress				0·2 per cent. proof stress				0·5 per cent. proof stress			
	Specimen extension (in.)	Time for extension (min.)	Average strain rate (in. per in. per min.)	0·1 per cent. proof stress (tons per sq. in.)	Specimen extension (in.)	Time for extension (min.)	Average strain rate (in. per in. per min.)	0·2 per cent. proof stress (tons per sq. in.)	Specimen extension (in.)	Time for extension (min.)	Average strain rate (in. per in. per min.)	0·5 per cent. proof stress (tons per sq. in.)
1	0·0060	0·66	0·0046	15·2	0·0082	0·72	0·0057	15·8	0·0146	0·87	0·0084	16·9
2	0·0058	1·00	0·0029	14·9	0·0080	1·10	0·0036	15·5	0·0144	1·35	0·0053	16·7
3	0·0058	2·06	0·0014	14·4	0·0080	2·30	0·0017	15·0	0·0143	2·84	0·0025	16·2
4	0·0057	4·75	0·00060	14·2	0·0079	5·12	0·00077	14·7	0·0142	6·00	0·0012	15·8
5	0·0057	13·08	0·00022	14·1	0·0078	14·00	0·00028	14·3	0·0140	16·70	0·00042	15·1
6	0·0058	19·75	0·00015	14·0	0·0076	20·95	0·00018	14·2	0·0138	25·75	0·00027	15·0

TABLE III.—*Influence of Speed of Testing on Proof Stress of Annealed Titanium-Aluminium-Manganese Rod.*

Test No.	0·1 per cent. proof stress				0·2 per cent. proof stress				0·5 per cent. proof stress			
	Specimen extension (in.)	Time for extension (min.)	Average strain rate (in. per in. per min.)	0·1 per cent. proof stress (tons per sq. in.)	Specimen extension (in.)	Time for extension (min.)	Average strain rate (in. per in. per min.)	0·2 per cent. proof stress (tons per sq. in.)	Specimen extension (in.)	Time for extension (min.)	Average strain rate (in. per in. per min.)	0·5 per cent. proof stress (tons per sq. in.)
1	0·0130	1·05	0·0062	41·8	0·0155	1·08	0·0072	42·6	0·0215	1·13	0·0095	43·0
2	0·0123	2·20	0·0028	41·1	0·0145	2·27	0·0032	41·8	0·0209	2·38	0·0044	42·5
3	0·0133	8·25	0·00082	39·8	0·0154	8·50	0·00091	40·5	0·0215	9·00	0·0012	41·2
4	0·0130	29·7	0·00022	38·0	0·0152	31·0	0·00025	38·8	0·0214	33·6	0·00032	39·2

The results of these tests are given in Tables IV and V and Figs. 3 and 4.

DISCUSSION

Fig. 1, Fig. 2, Table II and Table III, indicate that the room-temperature proof-stress values of both materials under consideration were affected by the speed at which testing was carried out. For example, the 0·5 per cent. proof stress of the titanium sheet increased from 15 tons per sq. in. when the strain rate was approximately 0·0003 in. per in. per min. to almost 17 tons per sq. in. when the rate of testing was increased to about 0·008 in. per in. per min. Figures for the titanium-aluminium-manganese alloy were approximately 39 tons per sq. in., and 43 tons per sq. in. for a comparable range of strain rates.

The results included in Table IV and Fig. 3 indicate that the tensile strength of the commercially-pure material increased from about 23 tons per sq. in. to over 26 tons per sq. in. as the average rate of strain was increased from about 0·01 in. per in. per min. to 1 in. per in. per min., elongation values decreasing, over this testing range, from about 45 per cent. to 32 per cent. For the titanium alloy, the tensile-strength values were about 46 tons per sq. in. and 49 tons per sq. in., respectively, for average strain rates of about 0·01 in. per in. per min. and 1 in. per in. per min., the corresponding elongation values being 32 per cent. and 21 per cent.

From an analysis of the plotted data, it was established, for both materials, that values, σ, for proof stress and ultimate tensile strength could be related to average strain-rate values, $\dot{\epsilon}$, expressed as in. per in. per min., by the approximate relationship

$$\sigma = C\,\dot{\epsilon}^{0\cdot0272} \text{ tons per sq. in.}$$

The value of C for the commercially-pure metal was found to be different from that for the titanium-aluminium-manganese alloy. For example, C was equal to 17·5 for the 0·1 per cent. proof stress of the commercially-pure material, the corresponding value for the alloy being 47·4. Similarly, C values for the tensile strength of the titanium and of the titanium alloy were 26·2 and 49·5 respectively. By a similar process, percentage-elongation values, e_T, which, it will be remembered, were measured over a gauge length of 2 in. (commercially-pure material) or $4\sqrt{A}$ (titanium-aluminium-manganese alloy) could be related by the approximate equation

$$e_T = \frac{C}{\dot{\epsilon}^{0\cdot0845}}$$

where C = 31·3 for commercially-pure titanium, and 21·1 for the titanium-aluminium-manganese alloy.

These relationships are also of interest inasmuch as they indicate approximately the effect on tensile properties, of a given alteration in the rate of straining. For example, they suggest that a two-fold increase in the average strain rate will change proof-stress values for both commercially-pure material and the alloy by about 2 per cent., the corresponding figure for percentage elongation being about 6 per cent. Jones and Moore,[1] whose investigations have been mentioned earlier, recorded the percentage changes in tensile properties associated with a two-fold increase in average rate of strain, and a comparison was therefore made between their results and those obtained in the present work. In this connection, it should be noted that although the method adopted by Jones and Moore to determine average strain-rate values was slightly different from the one indicated above, this should not significantly alter the general conclusions. Details of the comparisons will not be recorded here; in fact, they suggested that the commercially-pure titanium and the titanium-aluminium-manganese alloy considered in the present investigation were rather more sensitive to strain-rate effects than several steels, brass or Duralumin.

The results of the present investigation, therefore, together with the published information referred to earlier,[4–7] indicate that for results to be in good agreement, tensile tests on titanium-base materials should be carried out using average strain rates which fall within a fairly

TABLE IV.—*Influence of Speed of Testing on Ultimate Tensile Strength and Elongation of Annealed Commercially-Pure Titanium Sheet*

Test No.	Ultimate tensile strength (tons per sq. in.)	Specimen elongation (per cent. on 2 in.)	Time to fracture specimen (min.)	Average strain rate (in. per in. per min.)
1	27·2	33	0·26	1·27
2	25·3	32	0·60	0·53
3	25·0	33	1·27	0·26
4	24·2	39	4·92	0·079
5	23·8	41	15·58	0·026
6	23·8	44	20·11	0·022
7	23·2	45	33·61	0·013

TABLE V.—*Influence of Speed of Testing on Ultimate Tensile Strength and Elongation of Annealed Titanium-Aluminium-Manganese Rod*

Test No.	Ultimate tensile strength (tons per sq. in.)	Specimen elongation (per cent. on $4\sqrt{A}$)*	Time to fracture specimen (min.)	Average strain rate (in. per in. per min.)
1	48·7	21	0·35	0·60
2	48·0	24	0·73	0·33
3	47·3	23	1·35	0·17
4	46·5	26	2·70	0·096
5	46·3	26	7·42	0·035
6	46·3	27	16·67	0·016
7	46·0	33	36·0	0·0092

* A = cross-sectional area in sq. in.

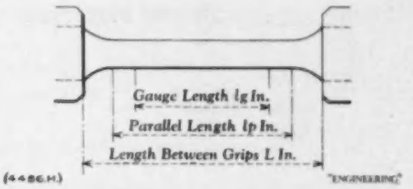


Fig. 5 Symbols used in analysis, and tensile specimen before fracture.

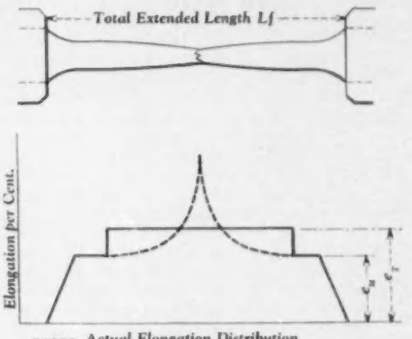

Total Extended Length Lf
Elongation per Cent.
Actual Elongation Distribution in Gauge Portion of Broken Test Piece
Average Value Used in Analysis. (This is the Value which is Recorded when Elongation, on $4\sqrt{A}$ for Example, is Determined)
(4486.E.)
"ENGINEERING"

Fig. 6 Elongation characteristics of broken tensile test piece represented schematically.

confined range, and in this connection, specifications are in fact in existence[8] which impose limits on the strain rates to be employed. These limits are, for proof stress, 0·002 in. per in. per min. to 0·005 in. per in. per min., and, for tensile strength, 0·15 in. per in. per min. to 0·30 in. per in. per min. It is clear, from earlier remarks, that the disparity of the results should be small if the strain rates are within these limits, but the problem of how to ensure that testing invariably meets the necessary requirements remains.

The determination of proof-stress values at definite rates of straining implies that unless a pacing type of instrument is employed, a close co-ordination of extension with time is necessary. This technique can be acquired after a little practice, although, on the other hand, such testing is not easily applicable to the determination of tensile strength. Furthermore, unless the total amount by which a specimen will elongate is approximately known beforehand, trial experiments are likely to be needed to establish the necessary testing conditions (for example, valve settings on hydraulically-operated machines) required to strain test specimens to fracture in appropriate times. It is appreciated that if only a small range of materials and types of specimen are to be tested, such a technique would be reasonably practicable; at the same time however, it would clearly be preferable to have available a test procedure designed to avoid the tedious work involved. Although equipment is available by means of which exploratory work of this nature can be avoided,[9, 10] it is of a complicated and expensive nature, and other means of overcoming the difficulties were therefore sought. With this end in view, a simple, yet widely applicable analysis has been made of certain aspects of the tensile test, leading to the definition of standard testing conditions, and this is now described.

PART II—TESTING CONDITIONS

Theoretical Considerations.—In this section, attention will be directed to the definition of testing conditions suitable for the determination of tensile strength at specified average rates of straining. Strain-rate values are influenced by

Continuing Metals and Materials

TABLE VII.—*Tensile Strength, Elongation, and Average Strain-Rate Values for Various Materials.*

Material	Nominal specimen diameter (in.)	Crosshead speed (in. per min.)	Tensile strength (tons per sq. in.)	Total elongation (per cent.) On 2 in.	On 1½ in.	On 1 in.	Calculated uniform elongation (per cent.) = e_u	Total elongation on $4\sqrt{A}$ (per cent.) = e_T	$K = e_u/e_T$	Time to fracture specimen (min.)	Average strain rate (in. per in. per min.)
H.C. copper	0·564	¼	14·8	57		74	40	57	0·70	5·79	0·100
	0·564	½	14·8	58		75	41	58	0·71	2·98	0·195
	0·424	¼	14·9	52	57	64	40	57	0·70	5·00	0·114
	0·424	½	14·8	52	57	66	38	57	0·67	2·52	0·226
	0·282	¼	15·1	45		54	36	54	0·67	4·15	0·130
	0·282	½	15·3	45		56	34	56	0·61	2·14	0·262
70/30 brass	0·564	¼	22·0	67		84	49	67	0·73	7·30	0·091
	0·564	½	22·1	69		86	51	69	0·74	3·60	0·190
	0·424	¼	22·2	65	70	77	53	70	0·76	6·60	0·105
	0·424	½	22·2	63	68	76	50	68	0·74	3·20	0·210
	0·282	¼	22·1	60		69	51	69	0·74	5·87	0·102
	0·282	½	22·1	58		66	50	66	0·76	2·88	0·202
Aluminium	0·564	¼	4·7	54		77	31	54	0·57	4·93	0·108
	0·564	½	4·7	52		73	29	52	0·56	2·20	0·236
	0·424	¼	4·7	47	55	64	30	55	0·55	4·18	0·132
	0·424	½	4·7	47	55	64	30	55	0·55	2·20	0·250
	0·282	¼	4·7	42		56	28	56	0·50	3·50	0·160
	0·282	½	4·7	42		54	30	54	0·56	1·85	0·292
Mild steel	0·564	¼	26·8	40		57	23	40	0·58	3·93	0·102
	0·564	½	26·9	40		55	23	40	0·58	1·97	0·203
	0·424	¼	26·6	36	42	51	21	42	0·50	3·28	0·128
	0·424	½	26·9	36	40	50	22	40	0·55	1·57	0·254
	0·282	¼	26·6	35		46	24	46	0·52	2·77	0·166
	0·282	½	26·1	32		44	20	44	0·46	1·37	0·321

several factors, the most important of which, from a practical point of view, are the speed of the testing machine cross-head, the ductility of the material being tested, and specimen geometry (i.e., gauge length, parallel length, etc.). The interaction of these factors leads to the difficulties already mentioned, and a simple theoretical relationship between them, therefore, was sought. It was assumed that the straining cross-head of the testing machine could be considered as moving, for virtually the whole of the tensile test, at a constant velocity relative to the fixed cross-head, and that the specimen would not slip or distort in the testing-machine grips.

The symbols used in the analysis are indicated in Fig. 5, which illustrates a tensile specimen before testing, and in Fig. 6, which refers to a fractured specimen, this latter figure also indicating, in an approximate manner, the distribution of elongation after fracture.[11] It should be noted that in the interests of simplicity, a linear distribution in the test piece fillets has been assumed in the present analysis.

Referring to Fig. 6, let the percentage uniform elongation be denoted by e_u and the total percentage elongation measured relative to the gauge length be e_T. Then if

$$a = \frac{e_u}{100} \text{ and } b = \frac{e_T}{100},$$

the length which was originally l_g in. (Fig. 5) will have become $l_g(1 + b)$ in. when the specimen has fractured. The length which was originally $(l_p - l_g)$ in. extends uniformly and becomes $(l_p - l_g)(1 + a)$ in., while each fillet length becomes $\frac{(L - l_p)\left(1 + \frac{a}{2}\right)}{2}$ in. Hence, at the moment of fracture, the total extended length L_f is:

$$L_f = l_g(1 + b) + (l_p - l_g)(1 + a) + (L - l_p)\left(1 + \frac{a}{2}\right) \text{ in.} \quad (1)$$

The corresponding total extension of the specimen is:

$$L_f - L = l_g(b - a) + \frac{(L + l_p)a}{2} \text{ in.} \quad (2)$$

If the speed of the testing machine cross-head, assumed to be constant, is denoted by S in. per min., then the fracture time t is given by:

$$t = \frac{\left\{l_g(b - a) + \frac{(L + l_p)a}{2}\right\}}{S} \text{ min.} \quad (3)$$

Therefore, since the average strain rate $\dot{\epsilon}$ of the gauge length is calculated by dividing the strain b of the gauge length by the time t,

$$\dot{\epsilon} = \frac{bS}{\left\{l_g(b - a) + \frac{(L + l_p)a}{2}\right\}} \text{ in. per in. per min.} \quad (4)$$

or, if the ratio of uniform elongation to gauge length elongation $\frac{a}{b}$ is denoted by K, as:

$$\dot{\epsilon} = \frac{S}{\left\{l_g(1 - K) + \frac{(L + l_p)K}{2}\right\}} \text{ in. per in. per min.} \quad (5)$$

Experimental.—To assess the validity of equation (5), and, therefore, its suitability for the definition of new testing techniques, tests were carried out using a 10 ton tensile testing machine of the type in which the moving cross-head is mechanically driven at a constant velocity. A two-speed motor was fitted to the machine, giving cross-head speeds of ¼ in. per minute and ½ in. per minute. Specimens were prepared from high-conductivity copper, 70/30 brass, commercially-pure aluminium and mild steel, several test pieces having gauge portion diameters nominally equal to 0·564 in., 0·424 in. and 0·282 in. being machined from each material.

Before carrying out any tests, each specimen was measured to determine the length of the parallel portion and the corresponding length between the shoulders, the values obtained being recorded in Table VI.

TABLE VI.—*Dimensions of Test Specimens*

Nominal specimen diameter (in.)	0·564	0·424	0·282
Gauge length l_g (in.) = $4\sqrt{A}$	2	1½	1
Approximate parallel length l_p (in.)	2½	2½	2½
Approximate length between grips L (in.)	3½	3	3

Gauge marks for the determination of elongation were scribed on every test piece at ½ in. intervals, and all specimens were then broken, each test piece being extended continuously, i.e., the cross-head was moving at one or other of the above constant speeds until fracture occurred. The time taken to fracture each specimen was noted, and average strain-rate values were calculated by dividing the elongation, measured on gauge lengths equal to $4\sqrt{\text{area}}$, by the corresponding test period.

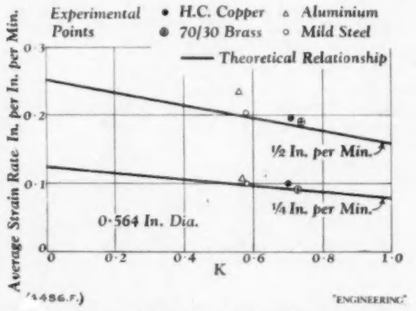


Fig. 7 Theoretical and experimental strain-rate values for 0·564 in. diameter test pieces.

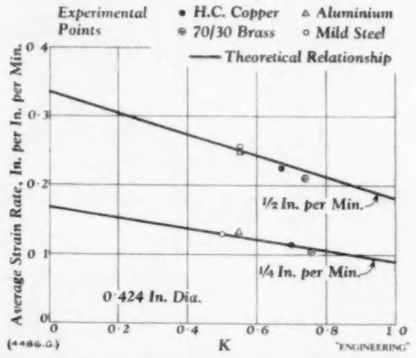


Fig. 8 Theoretical and experimental strain-rate values for 0·424 in. diameter test pieces.

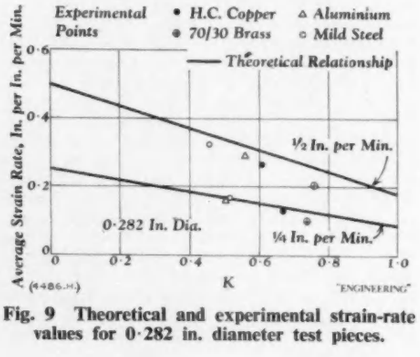


Fig. 9 Theoretical and experimental strain-rate values for 0·282 in. diameter test pieces.

Finally, the uniform elongation e_u of each specimen was calculated using a relationship derived from the expression for specimen elongation proposed by Unwin[12], which, as indicated by Cook and Larke[11] provides a reliable figure for uniform elongation. The derived relationship is: $e_u = 2e_2 - e_1$ where e_2 = percentage elongation measured on a 2 in. gauge length and e_1 = percentage elongation measured on a 1 in. gauge length.

The results obtained are recorded in Table VII, which also includes data for ultimate tensile strength and the ratio $\frac{e_u}{e_T}$ calculated from the experimental results.

APPLICATION TO TITANIUM-BASE MATERIALS

Results included in Table VII for average strain-rate values have been plotted as points in Figs. 7, 8, and 9, against the corresponding ratio K. Also drawn in these figures are lines derived from equation (5) by substituting values for l_g, l_p and L recorded in Table VI. It will be seen that the standard of agreement between these lines and the experimental points is quite good, this indicating that average strain rate, cross-head speed, specimen dimensions and

material ductility have been satisfactorily related by the simple expression (5).

Considering the theoretical lines drawn in Figs. 7, 8 and 9 in relation to the limits specified for titanium-base materials[8], it is clear that average strain rates associated with the particular type of 0·564 in. diameter test pieces fractured in the experimental work using a cross-head speed of $\frac{1}{2}$ in. per minute should always fall inside the specified range, irrespective of the elongation characteristics of the material.

Strain rates for the 0·424 in. diameter specimens, tested at a speed of $\frac{1}{2}$ in. per minute, should fall inside the range 0·33 in. per in. per min. to 0·18 in. per in. per min., the higher value, therefore, being slightly above the maximum specified limit. However, the lines drawn in Fig. 8 indicate that unless the material under test had an extremely low elongation ratio, i.e., $K < 0{\cdot}2$, strain rates should fall inside the proposed limits. Equation (5) indicates that for operating conditions always to be in conformity with the proposed limits, the speed of the machine cross-head would have to be 0·45 in. per min.

If the type of 0·282 in. diameter specimen tested in the present investigation were fractured at a speed of $\frac{1}{2}$ in. per minute, the associated strain-rate values might possibly be higher than the maximum proposed limit—see Fig. 9—while at a testing speed of $\frac{1}{4}$ in. per minute, strain rates could be less than the minimum limit. The application of equation (5), however, suggests that at an intermediate speed of $\frac{1}{8}$ in. per minute, strain rates would be acceptable provided that K values fell between 0·2 and 0·9, i.e., a wide range of ductility characteristics. This speed, therefore, should be reasonable for specimens in which $l_p \simeq 2\frac{1}{2}$ in. and L $\simeq$ 3 in., these dimensions often being necessary when proof-stress values are to be established. If, however, only ultimate tensile strength were to be determined, a test piece could be designed to meet specification requirements whatever its elongation characteristics. Thus, for a specimen having a parallel length l_p of $1\frac{1}{8}$ in. and a length L of $1\frac{1}{2}$ in. (these dimensions conforming to B.S.18), the associated strain rate, when fractured at $\frac{1}{4}$ in. per minute, would always fall inside the limits 0·15 in per in. per min. and 0·3 in. per in. per min.

Considering the dimensions of the type of specimen normally employed in tests on plate or sheet material—i.e., test piece A of B.S.18—these are often such that $l_g = 2$ in., $l_p \simeq 2\frac{1}{2}$ in. and L $\simeq 4\frac{1}{2}$ in. Substituting these values into equation (5) indicates that if a cross-head speed of 0·6 in. per minute were employed to fracture such a specimen average strain rate values would always fall inside the specified limits whatever the elongation characteristics of the material being tested.

The various testing conditions discussed above, i.e., for commonly-used test pieces, are summarised in Fig. 11, but it will be appreciated that before these can be put into practice effectively, a device indicating the rate of separation of the testing machine cross-heads is needed. This requirement applies particularly to hydraulically-operated testing machines, where, for example, a given setting of the operating valve may not always produce the same cross-head speed. Accordingly, a simple instrument was designed and constructed to indicate cross-head speed, and it is described in detail in the following section.

Specimen	Crosshead Speed (In. per Min.)
(1) 0·564" Dia.; Gauge Length 2"; Parallel Length Approx. 2½"; Length Between Shoulders Approx. 3¾"	0·5
(2) 0·424" Dia.; Gauge Length 1½"; Parallel Length Approx. 2½"; Length Between Shoulders Approx. 3"	0·45
(3) 0·282" Dia.; Gauge Length 1"; Parallel Length Approx. 2½"; Length Between Shoulders Approx. 3"	0·33
(4) 0·282" Dia.; Gauge Length 1"; Parallel Length Approx. 1⅛"; Length Between Shoulders Approx. 1½"	0·25
(5) 0·500"; Gauge Length 2"; Parallel Length Approx. 2½"; Length Between Shoulders Approx. 4½"	0·6

Note: When Possible, Specimen (4) Should be Used in Preference to Specimen (3)

(44864) "ENGINEERING"

Fig. 11 (left) Recommended testing conditions for the determination of the tensile strength of titanium-base materials.

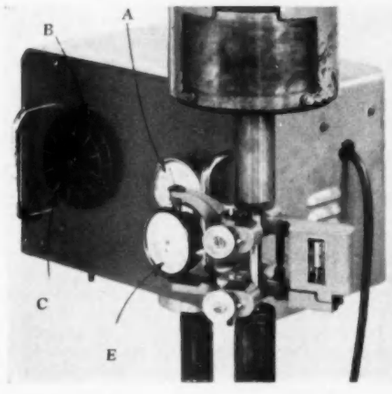


Fig. 10 (above) Pacing instrument in operating position.

PART III—PACING INSTRUMENT

Design of Instrument.—It is clear that the full range of testing speeds recommended in Fig. 11 can most easily be obtained by use of a hydraulically-operated testing machine, and the instrument described below was designed with this in mind. Furthermore, although the instrument was developed primarily to facilitate the determination of tensile strength of titanium-base materials at standardised average strain rates, provision was also made in the design to meet specification requirements in respect of proof stress.

The instrument is illustrated in its operating position in Fig. 10; visible on the front panel is dial A (this is actually an extensometer dial with the internal gear mechanism removed) and two co-axial graduated discs B and C. A stand supports the instrument at a convenient operating height. The mechanism of the instrument is shown in Fig. 12, the motor M—operating at 1 r.p.m.—driving the pointer of dial A in Fig. 10 by means of a spindle, which also carries a pulley P. This drives a second pulley P_1, identical with P, which is attached to a hollow shaft mounted in ball bearings fitted inside the housing H. This hollow shaft carries the rear graduated disc B, visible in Fig. 10, and it is clear that when the motor M is operating, the disc B will rotate at 1 r.p.m. Graduated disc C is attached to a spindle carried in bearings inside the hollow shaft, pulley P_2 (Fig. 12) being fixed to the inner spindle and driven by the train of pulleys visible in Fig. 12. The input spindle IS of this train projects from the back of the instrument and carries a pulley CP which is driven by a cord attached to the moving cross-head of the testing machine. A series of pulleys CP is provided to correspond to the various cross-head speeds recommended above, the effective pulley diameter d being determined from the relationship

$$d = \frac{S_r}{\pi} \text{ in.}$$

where

S = the required cross-head speed (in. per min.) and r = the effective speed ratio of the pulley train visible in Fig. 12.

This relationship means that for a given pulley CP, the graduated disc C will rotate at 1 r.p.m.

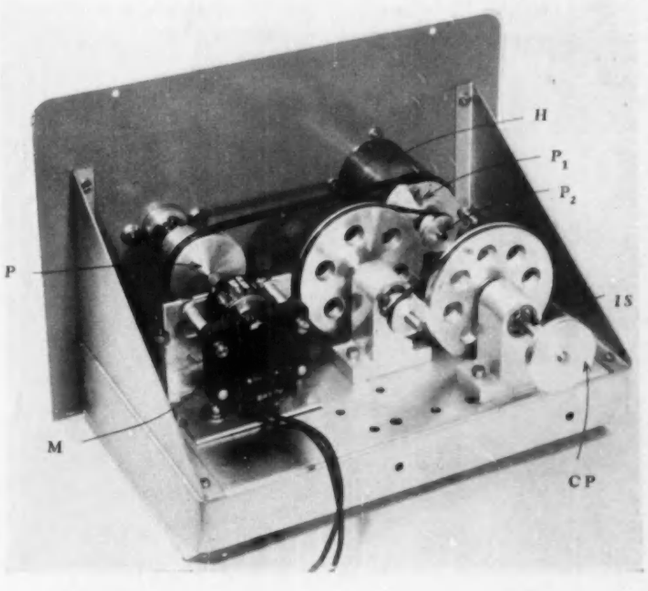


Fig. 12 (right) Internal mechanism of pacing instrument.

when the speed of the cross-head is correct—i.e., discs B and C will move in unison only when the cross-head is moving at the required speed.

Standardised Method of Testing.—Referring to Fig. 10, the operating position of the instrument is such that dial A and dial E of the extensometer* are conveniently and clearly visible to the testing machine operator. The pulley CP (Fig. 12) corresponding to the appropriate testing speed mentioned above is then fitted to the spindle IS, after which a cord is passed over this pulley and attached to the testing machine cross-head. A suitable operating tension is then obtained by applying a weight of about 2 lb. to the free end of the cord.

During a test, the machine operator adjusts the straining valve until the pointer of dial E is moving in unison with the pointer of dial A. As explained above, this latter pointer is driven at 1 r.p.m., and consequently the pointer of dial E will also be rotating at this speed. For the extensometer shown in Fig. 10, one revolution of this pointer represents a gauge-length extension of 0·005 in., so that the rate of straining will be 0·0025 in. per in. per min., this strain rate falling between the limits mentioned earlier in the article. While a test is in progress, a second observer notes the load corresponding to given convenient increments of extension, and in this manner, the required load/extension curve can be plotted. When the extension of the specimen is sufficient for proof stress values to be determined, the extensometer is removed, and the operating valve is opened until the two discs B and C move in unison, this correlation of speeds being maintained until the specimen has been fractured. The average strain rate $\dot{\epsilon}$ associated with this second part of the test is then calculated from the relationship:—

$$\dot{\epsilon} = \frac{\left\{\frac{e_T}{100} - \frac{e_E}{2}\right\}}{t} \text{ in. per in. per min.}$$

where

e_T = total elongation per cent. measured on $4\sqrt{A}$ for round specimens and on 2 in. for flat specimens.

e_E = maximum extension measured by the extensometer (in.). (The above relationship only applies to instruments having a 2 in. gauge length.)

and

t = the time (min.) which elapses between removing the extensometer and fracturing the specimen.

If only tensile strength values are to be determined, the technique just described for the second part of a full tensile test is applied, discs B and C being kept in unison throughout the entire test period. Then, as indicated in the previous section, unless the ductility characteristics of the material fall outside widely separated limits, the average strain-rate values will always meet the requirments of the specifications dealing with tests on titanium-base materials.

Acknowledgments.—The author's thanks are due to Mr. G. F. Bidmead, who carried out the numerous tensile tests, and to Mr. B. Chance, who constructed the special pacing instrument.

* It should be noted that the instrument was designed to be used in conjunction with a dial-gauge type of extensometer having a gauge length of 2 in., and illustrated in Fig. 10.

REFERENCES

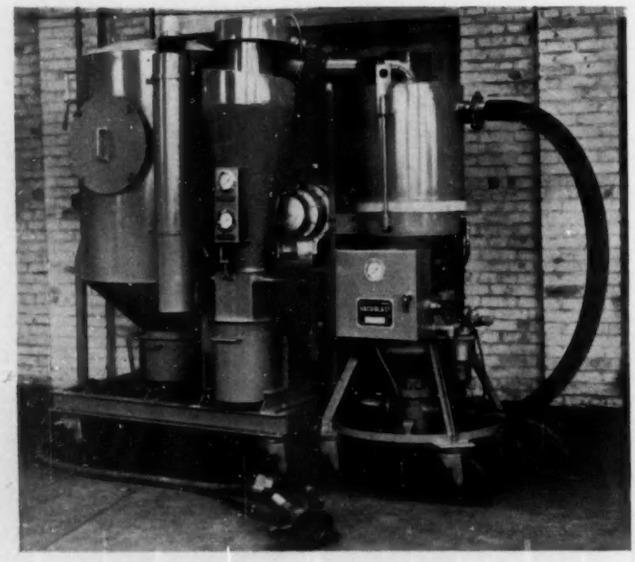
[1] Jones, P. G., and Moore, H. F. *Proc. A.S.T.M.*, vol. 40, page 610 (1940).
[2] Moore, A. A. *Proc. A.S.T.M.*, vol. 48, page 1133 (1948).
[3] Walker, J. L. *Metallurgia*, October, 1945, page 249.
[4] *Republic Titanium and Titanium Alloys.* Republic Steel Corporation Handbook, 1954.
[5] Kotfila, R. J., and Erbin, E. F. *Metal Progress*, vol. 66, page 128 (1954).
[6] Rosi, F. D., and Perkins, F. C. *Trans. A.S.M.*, vol. 45, page 972 (1953).
[7] Kondo, Y., and Suzuki, S. *Sumitomo Metals*, vol. 8 (3), page 26 (1956).
[8] D.T.D. 5003, 5013, 5023, 5033 and 5043.
[9] Hyde, L. K. *Proc. A.S.T.M.*, vol. 48, page 1191 (1948).
[10] Bernhard, R. K. *A.S.T.M. Bulletin*, October, 1940, page 31.
[11] Cook, M., and Larke, E. C. *J. Inst. Met.*, vol. 55, (2), page 165 (1934).
[12] Unwin, W. C. *Proc. Inst. Civil Eng.*, vol. 155, (1), page 170 (1903-1904).

Plant and Equipment

MACHINE FOR DUST-FREE GRIT BLASTING

Among the exhibits shown by Vacu-Blast Limited, 291 Aberdeen-avenue, Slough, Buckinghamshire, at the recent Engineering, Marine, Welding and Nuclear Energy Exhibition, in London, was the firm's new Major machine which allows dust-free grit blasting to be carried out anywhere in a works or in the open. The system, it is stated, affords instantaneous recovery of both the abrasive and the debris arising from the grit blasting. There are no installation costs, and no protective clothing is required. The machine consists of a generator-reclaimer unit and a dust collector fitted with a 15-h.p. electric motor and starter. These two sections can be integrated to form a single unit or they may be separated at a distance of 75 ft. apart, if circumstances require the operation of the dust collector in a position remote from the generator-reclaimer.

A general view of the Major machine is shown in the accompanying illustration. On the right is the generator-reclaimer section mounted on four castors and on the left is the dust-collector unit, also on four castors. In the base of the generator-reclaimer is a pressure feed hopper from which abrasive is drawn by means of compressed air at a pressure of 100 lb. per sq. in. and passed to the blast "gun" seen on the floor in front of the machine. To facilitate its manipulation and to enable it to be kept down easily on the surface undergoing treatment, the gun is mounted on three rollers. Attached to it is also a vacuum hose which draws off the abrasive as soon as it has done its work and recovers also the dust and debris produced during the blasting operation. A variety of abrasives may be employed, depending on the type of surface to be cleaned and the finish required. Abrasive consumption varies between 3 lb. and 6 lb. per blasting hour and the machine requires 130 cub. ft. of clean dry air per minute at a pressure of 100 lb. per sq. in.



Grit-blasting machine affording instantaneous recovery of both abrasive and debris. It consists of a generator-reclaimer unit on the right and a dust-collector unit on the left. The blast "gun," on three rollers, is seen on the floor in front of the machine.

The vacuum hose takes the recovered abrasive, dust and debris to the top of the generator-reclaimer unit where the abrasive is separated from the other recovered materials. The abrasive is air-washed, sieved and returned through special dump valves to the pressure feed hopper for re-use. The dump valves are automatically opened and closed for the transfer of the abrasive by means of a secondary compressed-air supply.

The dust and debris, after the separation of the abrasive, pass into the dust collector, where the greater part of the heavier dust is deposited in the base of the conical cyclone-type separator seen in the centre of the illustration. The final cleaning of the dust-laden air is carried out in the cylindrical air-filter unit seen on the left in the illustration. Here sock-type filters, having a high cloth to air ratio, ensure the efficiency of the cleaning operation.

The Vacu-Blast machine can be supplied as a continuous cycling (C.C.) or a non-continuous (N.C.) unit according to the specific requirements of the user. The C.C. type of machine ensures a continuous supply of abrasive and is required for mechanised operations where grit blasting must continue for several hours without interruption, whereas the N.C. unit requires a brief interruption of the blasting for approximately 30 seconds every five or six minutes. The N.C. model is more generally preferred for all discontinuous grit-blasting operations.

The machine can be used with several attachments for a wide variety of grit-blasting operations. In addition to a high-production gun for plate de-scaling, there is a standard gun, long gun and small gun for vertical and overhead blasting, a dual gun for plate-edge preparation and a selection of attachments for cleaning tubes from $\frac{1}{8}$ in. bore upwards. Blast cabinets can also be supplied for cleaning intricate castings and a pass-through cabinet for cleaning structural sections is also available. Both cabinets are operated in conjunction with the Major machine.

We are informed that in the few months since the machine was first made available it has been installed in shipyards for de-scaling heat-treated mild-steel plates and grit-blasting ships' hulls, on nuclear-power sites for cleaning heat exchangers, in a steam-turbine factory for cleaning steam and oil pipes, in a rolling-mill shop for grit-blasting working rolls, in railway repair depots for rolling-stock maintenance and in a boiler shop for weld preparation in the fabrication of pressure vessels.

Continuing **Plant and Equipment**

Oxy-acetylene rivet-heating furnace for shipyards which can be carried to the scene of almost every operation on shipboard.

OXY-ACETYLENE RIVET HEATING FURNACE

The conventional method of heating rivets in shipbuilding yards is by means of a coal fire and, although the fires are portable, they cannot always be brought direct to the place where riveting is carried out. In such cases, an additional operator, usually known as a "catcher," is required to complete a riveting crew.

A new oxy-acetylene rivet-heating furnace, developed at Chester-le-Street, County Durham, by British Oxygen Gases Limited, Spencer House St. James's-place, London, S.W.1, can be carried to the scene of almost every operation, and the need for a catcher is eliminated. A general view of the new furnace is shown in the accompanying illustration. The rivets are heated by a specially adapted burner which is fitted to one of the firm's Weldogen blow-pipe shanks. Supplies of oxygen and acetylene, which are fed from a header, are controlled by a duplex valve.

The Middle Docks and Engineering Company, Limited, South Shields, County Durham, are now using two of the new furnaces. One is capable of heating 80 rivets an hour, with a consumption of 35 cub. ft. of oxygen and acetylene per hour. The other furnace can heat 50 rivets an hour, using less gas.

In addition to the elimination of the catcher, a number of other advantages are claimed. As there are no fumes, they can be used in confined spaces. There is no danger of damage to a ship's woodwork by excessive smoke and there is also no danger of hot dross and ash falling on to the deck. Furthermore, the furnaces can be used in the engine room, when the engine is open, as there is no possibility of grit being deposited on cylinder bores and into bearings.

★ ★ ★

SPARES PACKAGING

For packing spares, a lightweight fibrous material has been devised by Resil Products Limited, Pontefract, Yorkshire, which can be moulded to the exact shape of the part to be packaged, and then enclosed in a cardboard box. Having a high degree of resilience, the packing protects the contents from rough handling.

One firm which is using this type of moulding is Megator Pumps and Compressors, Limited, 43 Berkeley-square, London, W.1. Whereas previously the spare rotors for their pumps were packed in wooden boxes, now each is simply placed between the two mouldings and the cardboard outer box is sufficient covering even for overseas dispatch.

Marketing

RE-AWAKENING IN THE LEVANT

There are signs that the trade position of Britain in the Middle East is improving, albeit more slowly than anticipated by some of the more experienced salesmen in the area. The Russian influence has extended rather more deeply, and the American counter-influence more widely, than could have been forecast when the Suez Canal was re-opened. Both these countries use capital as a means of furthering their influence, and both are busy laying the foundations of a major export business even if in the initial stages it means exporting at a loss.

There is little doubt that the position of the British exporter, who before the crisis was finding that competition from Germany was increasing, is now worse than before. Yet salesmanship and the intimate knowledge of the area accumulated by some firms after half a century or more of trading can win the day. Two such companies, Metropolitan-Vickers and Marconi's Wireless Telegraph have just secured major contracts in Iraq and Turkey, respectively. Metropolitan-Vickers have an order worth nearly £200,000 for three steam turbo-generators and auxiliaries to be fitted into a new power station at Basrah, Iraq's port on the Persian Gulf. Marconi have obtained a contract worth £1 million from the Turkish Radio Administration for the complete re-organisation of the long-wave broadcasting station at Ankara, including the doubling of the power and a considerable extension of the studio facilities. These major successes should encourage other firms to resume their sales efforts there.

★ ★ ★

Design for Europe

Overseas practice and accepted standards have for long limited British exports of electrical plant and appliances. This is particularly so in Europe and considerable adjustments (or relaxation of rules) will have to be made if British trade in these products with common market countries is to expand significantly. With this in mind, the General Electric Company has developed a completely new range of electrical unit heaters, from 3 kW to 20 kW, "which comply with the special requirements of American, Swedish, Norwegian and Swiss standards, as well as those of the projected European Common Market and of the United Kingdom."

The heaters comply with the test-finger specification required; all live and moving parts are screened; and safety switches are provided as a guard against overheating. The company emphasise that they have taken special pains to improve the appearance of the heaters. This is of the greatest importance in about every overseas market, but particularly in North America and in the Continent of Europe, where the styling of British electrical equipment has long been the subject of criticism. There is little doubt that G.E.C.'s policy is correct if trade with Europe is to grow, for in this industry differences in regulations, rather than import quotas and tariffs, restrict British exports.

★ ★ ★

Preparing for Free Trade

The implications of the Free Trade Area proposals are to be the subject of a one-day conference to be held on October 28 by the Incorporated Sales Managers' Association at the Royal Festival Hall, London. Lord Woolton will preside and Mr. Reginald Maudling, who is the Minister (recently promoted to Cabinet rank) in charge of the negotiations with European countries, will review progress. Mr. Leslie Gamage, vice-chairman of the General Electric Company and a prominent member of trade promotion organisations, will discuss the industrial and commercial implications of free trade.

The theme for the conference is the action business managers can take now to "minimise the threat and maximise the opportunities" which are implied in the proposal that Britain should join a free trade area. The sales managers look upon it as a challenge. The statement announcing the conference is both apt and stimulating, although it may err on the side of idealism when it asks: "In shaping our sales plans to meet the challenge of European Free Trade, what facts and opinions should be collected and examined? What techniques are available and what should be our attitude towards their use?" Quite rightly, they point out that these questions will have to be answered by management executives during the coming months. They will also discuss the technical implications of free trade, ability of British industry to apply new inventions and materials, and the influence of national standards and regulations on the competitive ability of British industry. Not least they will concern themselves with the rôle of the salesmen which, the freer the trade, the more vital it becomes.

★ ★ ★

Reserved for Export

After the war, British industry was encouraged to keep its best and newest products for "export only." The British public particularly was kept waiting for cars, high-quality clothing, toys and household equipment of all kinds. Industry was on the whole better treated, on the grounds that it had at least an equal claim to the engineering industry's discoveries if it was to keep abreast of technical change and not yield the lead to foreign competitors.

An announcement by the Package Sealing Company that their automatic band strapping machine had recently become available for home users after being supplied to factories in Canada, Denmark, Switzerland, Holland and France—"where it has achieved great success"—will be welcomed. Yet some may resent that a product described by the manufacturers as "the greatest advance for many years in the field of tensional steel strapping" should first benefit their competitors overseas. Still, there is merit in the attitude that exports come first. Little can be said to carry a higher priority.

★ ★ ★

Higher Advertising Expenditure

Competition from television is not so far reducing the amount spent on advertising in the Press. During the second quarter of this year expenditure on Press advertising exceeded £25 million, nearly 2 per cent. more than in the same quarter of 1956 and only slightly below the highest level ever reached, in the fourth quarter of the same year. The figures published in the Statistical Review of Press Advertising show that the amounts spent on tobacco and paint—about £½ million each in the quarter—had sharply increased. I.C.I. was one of the top spenders, with over £59,000.

The tremendous increase in expenditure on television advertising continues. In the second quarter of this year it was over £7 million, an increase of £4·5 million over the 1956 level. The rapid progress made by the independent operators was the subject of a note in these columns in the issue of August 30. We regret that in that note the company referred to should have been Associated Rediffusion and not Associated Television as stated. The managing director of A.T.V. is Mr. Val Parnell; Mr. Paul Adorian manages Associated Rediffusion.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *July* 26, *page* 126; *or August* 30, *page* 274. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

National Cattle and Agricultural Machinery Fair.—Early in October, at Quinta Normal, Santiago. Organised by the Sociedad Nacional de Agricultura, Tenderini 187, Santiago, Chile.

Gas Council's Fifth Sales and Service Conference.—Tues., Oct. 1, to Thurs., Oct. 3, at the Hotel Majestic, Harrogate, Yorkshire. General Theme: The Need for Training and Organisation in Salesmanship. Organised by the Gas Council, 1 Grosvenor-place, London, S.W.1. Tel. SLOane 4554.

Lubrication and Wear, Conference.—Tues., Oct. 1, to Thurs., Oct. 3, technical sessions in London. In addition, Mon., Sept. 30 and Fri., Oct. 4, will be devoted to whole-day and half-day excursions. Some of the papers will be re-discussed at subsequent meetings in Toronto and New York. Organised, with the collaboration of the American Society of Mechanical Engineers, by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

***National Smoke Abatement Society, 24th Annual Conference.**—Wed., Oct. 2, to Fri., Oct. 4, at the Queen's Hotel and the White Rock Pavilion, Hastings. Offices of the Society: Palace Chambers, Bridge-street, London, S.W.1. Tel. TRAfalgar 6838.

***Zaragoza National Fair, 17th.**—Wed., Oct. 2, to Sun, Oct. 20. Apply to Feria Nacional de Muestras, Zaragoza, Spain.

Plasma and Atomic Physics, Conference.—Thurs. and Fri., Oct. 3 and 4, at the Atomic Energy Research Establishment, Harwell. Apply to the secretary, the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Book Fair, Ninth International.—Sat., Oct. 5, to Thurs., Oct. 10, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Upper Thamesstreet, London, E.C.4. Tel. CENtral 5050.

Welding Exhibition "Lastu 57."—Sat., Oct. 5, to Sat., Oct. 12, in the "Margriethal," Utrecht, Holland. During the exhibition a two-day symposium on **The Metallurgy of the Welding of Steel** will be held. Organised by Nederlandse Vereniging voor Lastechniek, 62, Zeestraat, The Hague, Holland.

Electronics Conference Exhibit, National.—Mon., Oct. 7, to Wed., Oct. 9, in the Hotel Sherman, Chicago. Organised by the National Electronics Conference, Inc., 84 East Randolph-street, Chicago 1.

***Fishing Gear, International Congress on.**—Mon., Oct. 7, to Sat., Oct. 12, at Curio Haus, Erdgeschloss, Hamburg, Germany. Organised by the Food and Agriculture Organization of the United Nations, Viale delle Terme de Caracalla, Rome. See ENGINEERING, July 13, 1956, page 38. (Additional information.)

Films in the Service of Industry, Festival.—Tues., Oct. 8, to Sat., Oct. 12, at Harrogate, Yorkshire. Apply to the organising secretary, 3 Portman Chambers, 7 to 9 Baker-street, London, W.1. Tel. WELbeck 1104.

High Vacuum Technology, Fourth Annual Symposium.—Wed., Oct. 9, to Fri., Oct. 11, at the Hotel Somerset, Boston, Mass. U.S.A. Organised by the Committee on Vacuum Techniques, Box 1282, Boston 9, Mass., U.S.A.

Engineering Industries Association; 10th London Regional Display.—Wed., Oct. 9, to Fri., Oct. 11, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Society, 9 Seymour-street, London, W.1. Tel. WELbeck 2241.

Uses of Timber, Symposium on.—Fri., Oct. 11, to Tues., Oct. 15, at Lodge Hill Residential College, Pulborough, Sussex. Organised by the Timber Development Association, 21 Collegehill, London, E.C.4. (Tel. CITy 4771.) Apply to the regional officer, 8 St. George's-place, Brighton 1.

Automatic Merchandising Convention and Exhibition.—Sun., Oct. 13, to Wed., Oct. 16, at the Convention Hall, Philadelphia. Organised by the National Automatic Merchandising Association, 7 South Dearborn-street, Chicago 3, Illinois, U.S.A.

***Corrosion Convention and Exhibition.**—*Convention:* Tues. and Wed., Oct. 15 and 16, at the Central Hall, Westminster, London, S.W.1. *Exhibition:* Tues., Oct. 15, to Thurs., Oct. 17, at the Royal Horticultural Society's Old Hall, Vincent-square, London, S.W.1. Organised by the Leonard Hill Technical Group, Stratford House, 9 Eden-street, London, N.W.1. Tel. EUSton 5911.

Institute of Radio Engineers, Convention and Exposition.—Wed., Oct. 16, to Fri., Oct. 18, at the Canadian National Exhibition Park, Toronto. Organised by the Institute of Radio Engineers, Canadian Section, 745 Mount Pleasant-road, Toronto 7, Ontario, Canada.

***Concrete Road Congress, International.**—Wed., Oct. 16, to Sat., Oct. 19, at the Congress Building, Esposizione Universale Roma, Rome, Italy. Apply to the Pavings Development Group, Terminal House, Grosvenor-gardens, London, S.W.1. Tel. BELgravia 6661.

Motor Show (42nd International Motor Exhibition).—Wed., Oct. 16, to Sat., Oct. 26, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Workmen's Safety and Factory Hygiene Congress and Exhibition.—Thurs., Oct. 17, to Sat., Oct. 19, at Dusseldorf. Sponsored by the German Society for Workmen's Safety. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Dusseldorf, Germany.

Electric and Atomic Show, International.—Fri., Oct. 18, to Sun., Oct. 27, at the Forum, Copenhagen. Organised by the Danish Electrical Development Association, Copenhagen, Denmark.

Canada's Power Show.—Mon., Oct. 21, to Thurs., Oct. 24, in the New Queen Elizabeth Building, Exhibition Park, Toronto. Organised by the Institute of Power Engineers, 199 Bay-street, Toronto, Ontario, Canada.

Coal Preparation, Second Symposium on.—Mon., Oct. 21, to Fri., Oct. 25, at The University, Leeds. Organised by the Coal Preparation Plant Association (P.O. Box 121), 301 Gossop-road, Sheffield 10. Tel. Sheffield 63031.

Fisheries Exhibition, International.—Mon., Oct. 21, to Sat., Oct. 26, at Lowestoft. Exhibition offices: Ludgate House, 110 Fleet-street, London, E.C.4. Tel. FLEet Street 6961.

Dairy Show, 71st Annual.—Tues., Oct. 22, to Fri., Oct. 25, at Olympia, London, W.14. Organised by the British Dairy Farmers' Association, 17 Devonshire-street, London, W.1.

***Radio Hobbies Exhibition** (Previously the **Amateur Radio Exhibition**).—Wed., Oct. 23, to Sat., Oct. 26, at the Royal Horticultural Society's Old Hall, Vincent-square, London, S.W.1. Organised by Radio Society of Great Britain, 28-30 Little Russell-street, London, W.C.1. Tel. HOLborn 7373.

***Engineers Joint Council and Engineers' Council for Professional Development, Fourth Annual General Assembly.**—Thurs. and Fri., Oct. 24 and 25, at the Hotel Statler, New York. Offices of both organisations: 29 West 39th-street, New York 18, U.S.A.

Scientific Instrument Manufacturers' Association (SIMA), Sixth Annual Convention.—Thurs., Oct. 24, to Sun., Oct. 27, at Eastbourne. Theme: "Enterprise 1958." Organised by the Association, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251.

Algiers International Trade Fair, 17th.—Fri., Oct. 25, to Mon., Nov. 11, in Algiers. Fair Offices: 3 Rue Jean-Rameau, Algiers, Algeria.

***Atomic Industrial Forum, Fourth Annual Conference.**—Mon., Oct. 28, to Wed., Oct. 30, at the Plaza and Waldorf-Astoria Hotels, New York, U.S.A. Organised by the Atomic Industrial Forum, 3 East 54th-street, New York 22.

***American Nuclear Society, Second Winter Meeting.**—Mon., Oct. 28, to Wed., Oct. 30, at the Henry Hudson Hotel, New York, U.S.A. Apply to the Atomic Industrial Forum, 3 East 54th-street, New York 22.

Materials Handling Convention.—Mon., Oct. 28, to Wed., Oct. 30, at Leamington Spa. Organised by the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254.

***Atomfair: Trade Fair of the United States Atomic Industry.**—Mon., Oct. 28, to Thurs., Oct. 31, at New York Coliseum, Broadway, New York, U.S.A. Sponsored by the Atomic Industrial Forum, 3 East 54th-street, New York 22.

National Protective Packaging and Materials Handling Exposition.—Mon., Oct. 28, to Thurs., Oct. 31, in Atlantic City. Communications to Hanson and Shea Incorporated, 1 Gateway Centre, Pittsburg, Pennsylvania, U.S.A.

Newspaper and Rotary Letterpress Conference.—Mon., Oct. 28, to Thurs., Oct. 31, at Harrogate. Organised by the Printing, Packaging and Allied Trades Research Association (PATRA), Patra House, Randalls-road, Leatherhead, Surrey. Tel. Leatherhead 4041.

South Wales Institute of Engineers, Centenary Celebrations.—Tues. and Wed., Oct. 29 and 30, in Cardiff and surrounding district. Apply to the secretary, the South Wales Institute of Engineers, Park-place, Cardiff. Tel. Cardiff 23296.

***Annealing of Low Carbon Steel, International Symposium.**—Tues. and Wed., Oct. 29 and 30, at the Case Institute of Technology, University Circle, Cleveland 6, Ohio, U.S.A. Organised jointly by the Case Institute and the Lee Wilson Engineering Co., Inc., Cleveland, Ohio, U.S.A.

***Careers in Nuclear Science and Engineering, Second Annual Conference.**—Wed., Oct. 30, at New York Coliseum, Broadway, New York U.S.A. Apply to the Atomic Industrial Forum, 3 East 54th-street, New York 22.

Library Services in Technical Colleges, Conference.—Wed., Oct. 30, at Connaught Rooms, Great Queen-street, London, W.C.2. Organised by Aslib, 4 Palace-gate, London, W.8. (KNIghtsbridge 0444.)

***Reactor Safety Conference.**—Thurs., Oct. 31, at New York Coliseum, Broadway, New York, U.S.A. Sponsored by the Atomic Industrial Forum, the American Nuclear Society and the United States Atomic Energy Commission. Apply to the Atomic Industrial Forum, 3 East 54th-street, New York 22.

World Metallurgical Congress, Second; and 39th National Metal Congress and Exposition.—Sat., Nov. 2, to Fri., Nov. 8, in Chicago. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

Measuring Instruments and Automation, International Congress and Exhibition (INTERKAMA).—Sat., Nov. 2, to Sun., Nov. 10, at the Ehrenhof Exhibition Grounds, Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany.

***Combustion Engineering Association's Conference.**—Tues. and Wed., Nov. 5 and 6, at the Old Swan Hotel, Harrogate. Theme: The Third Progress Survey of the National Industrial Fuel Efficiency Service. Organised by the Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. Tel. WHItehall 5536.

Canadian National Packaging Exposition, Sixth.—Tues., Nov. 5, to Thurs., Nov. 7, in the Automotive Building, Canadian National Exhibition Park, Toronto. Organised by the Packaging Association of Canada, 1 St. Clair-avenue West, Toronto 7, Ontario, Canada.

***Industrial Efficiency and Productivity Exhibition.**—Tues., Nov. 5, to Sat., Nov. 16, at the City Hall, Deansgate, Manchester. Sponsored by the Institution of Works Managers, 196 Shaftesbury-avenue, London, W.C.2. Tel. TEMple Bar 8324. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363. (Additional information.)

National Management Conference.—Wed., Nov. 6, to Fri., Nov. 8, at Bournemouth. Theme: "Research—A Signpost to Better Management." Organised by the British Institute of Management, 80 Fetter-lane, London, E.C.4. Tel. HOLborn 3456. See also ENGINEERING, August 2, page 133.

Special Libraries Association, Metals Division Meeting.—Wed., Nov. 6, to Fri., Nov. 8, in Chicago, Ill., U.S.A. Apply to Alvina Wassenberg, Kaiser Aluminum and Chemical Corporation, Department of Metallurgical Research, Spokane 69, Washington, U.S.A.

***Electrical Techniques in Medicine and Biology.**—Wed., Nov. 6, to Fri., Nov. 8, at the Sheraton Plaza Hotel, Boston, Mass., U.S.A. Sponsored by the American Institute of Electrical Engineers, the Institution of Radio Engineers' Medical Physics Group of Boston, U.S.A., and the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

BEAMA Publicity Conference.—Thurs. and Fri., Nov. 7 and 8, at the Connaught Rooms, Great Queen-street, London, W.C.2. Attendance restricted to staffs of member-firms of **BEAMA.** Apply to the British Electrical and Allied Manufacturers' Association, 36 and 38 Kingsway, London, W.C.2. Tel. HOLborn 0502.

Scottish Motor Exhibition.—Fri., Nov. 8, to Sat., Nov. 16, at Kelvin Hall, Glasgow. Organised by the Scottish Motor Trade Association Ltd., 3 Palmerston-place, Edinburgh 12. Tel. Edinburgh Central 3643.

British Sports Trade Fair.—Mon., Nov. 11, to Fri., Nov. 15, at the Kingsley Hotel, Bloomsbury-way, London, W.C.1. Organised by the Federation of British Manufacturers of Sports and Games Ltd., Panton House, 25 Haymarket, London, S.W.1. Tel. WHItehall 5845.

***Standards, Eighth National Conference on.**—Wed., Nov. 13, to Fri., Nov. 15, at the St. Francis Hotel, San Francisco, U.S.A. Sponsored by the American Standards Association, 70 East 45th-street, New York 17.

***Highway Needs of Great Britain, Conference.**—Wed., Nov. 13, to Fri., Nov. 15, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Organised by the Institution. Tel. WHItehall 4577.

***Society of Naval Architects and Marine Engineers, 65th Annual Meeting.**—Wed., Nov. 13, to Sat., Nov. 16, at the Waldorf-Astoria Hotel, New York, U.S.A. Offices of the Society: 74 Trinity-place, New York 6.

***Production Exhibition and Work Study Week.**—Mon., Nov. 18, to Fri., Nov. 22, at the Northampton College of Advanced Technology, St. John-street, London, E.C.1. Organised by the Northampton College and the Local Productivity Council

Developments in Industrial Low Temperature Gas Separation, One-Day Conference.—Tues., Nov. 26, at the Royal Institution, 21 Albemarle-street, London, W.1. Organised jointly by the Low Temperature Group of the Physical Society and the Institution of Chemical Engineers. Apply to the Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. Tel. KENsington 0048.

Smithfield Show and Agricultural Machinery Exhibition.—Mon., Dec. 2, to Fri., Dec. 6, at Earls Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, W.1. Tel. GROsvenor 4040.

Chemical Industries Exposition, 26th.—Mon., Dec. 2, to Fri., Dec. 6, at the New York Coliseum, New York. Organised by the International Exposition Co., 480 Lexington-avenue, New York 17, U.S.A.

***Combustion of Solid and Powdered Fuels, Conference.**—Wed., Dec. 4, to Sat., Dec. 7, at 7 Rue La Pérouse, Paris. Organised by the Institut Français des Combustibles et de l'Energie, 3 Rue Henri Heine, Paris 16e.

Solid State Physics, Second Conference.—Thurs. and Fri., Dec. 19 and 20, at Imperial College, London, S.W.7. Theme: "Band Theory of Metals and Experimental Investigations into the Structure of the Fermi Surface." Apply to the secretary, the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Recent Advances in Polymer Technology, Conference.**—Thurs., Feb. 27, 1958, probably at Institution of Civil Engineers, Great George-street, London, S.W.1. Organised jointly by the Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (Tel. BAYswater 9101); and the Plastics Institute, 6 Mandeville-place, London, W.1. Tel. WELbeck 5439.

***Packaging and Confectionery Machinery Fair (INTERPACK).**—Sun., Mar. 2, to Sun., Mar. 9, 1958, at Düsseldorf, Germany. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H., Ehrenhof 4, Düsseldorf. *Agents:* John E. Buck and Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576. (Additional information.)

***Physical Society's Exhibition of Scientific Instruments and Apparatus.**—Mon., Mar. 24, to Thurs., Mar. 27, 1958, in the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Technology of Engineering Manufacture, Conference.**—Tues., Mar. 25, to Thurs., Mar. 27, 1958, at the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Organised by the Institution in conjunction with its Applied Mechanics Group and its Industrial Administration and Engineering Production Group. Apply to the Institution, as above. Tel. WHItehall 7476.

Electron and Nuclear Resonance in Chemistry, Applications of; and Recent Work on the Inorganic Chemistry of Sulphur, Symposia.—Mon., Mar. 31, to Wed., April 2, 1958, at Bristol. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Prestressed Concrete, International Congress.—Mon., May 5, to Sat., May 10, 1958, in Berlin. Organised by the Fédération Internationale de la Précontrainte, Paris. Apply to Mr. P. Gooding, c/o the Cement and Concrete Association, Terminal House 52 Grosvenor-gardens, London, S.W.1. Tel. BELgravia 6661.

***High Polymers, International Conference.**—Mon., July 21, to Thurs., July 24, 1958, at The University, Nottingham. Organised by the Conference Secretariat, Department of Scientific and Industry Research, 5-11 Regent-street, London, S.W.1. Tel. WHItehall 9788.

***Peaceful Uses of Atomic Energy, Second International Conference.**—Mon., Sept. 1, to Sat., Sept. 13, 1958, at Geneva. Apply to the secretary, the executive committee, 1958 Geneva Conference, Atomic Energy Research Establishment, Harwell, Berks. See ENGINEERING, August 16, page 218.

Large Dams, International Commission on, World Power Conference.—Mon., Sept. 15, to Sat., Sept. 20, 1958, in New York. Communications to the secretary, British National Committee on Large Dams, 201-202 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966.

Gearing, International Conference.—Week commencing Mon., Sept. 22, 1958, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

***Future of Structural Engineering.**—Tues., Oct. 7, to Fri., Oct. 10, 1958. Fiftieth Anniversary conference of the Institution of Structural Engineers, to be held at its headquarters, 11 Upper Belgrave-street, London, S.W.1. Tel. SLOane 7128.

***Textile Machinery and Accessories Exhibition.**—Wed., Oct. 15, to Sat., Oct. 25, 1958, at Belle Vue, Manchester. Organised by Textile Recorder Exhibitions Ltd., Old Colony House, South King-street, Manchester 2. Tel. Deansgate 6903.

Electronic Computer Symposium and Exhibition.—Fri., Nov. 28, to Thurs., Dec. 4, 1958, at Olympia, London, W.14. Apply to Mr. J. F. Richardson, technical secretary, Radio Communication and Electronic Engineering Association, 11 Green-street, London, W.1. Tel. MAYfair 7874.

***Engineering Exhibition (22nd Engineering, Marine, Welding and Nuclear Energy Exhibition).**—Thurs., April 16, to Thurs., April 30, 1959, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

***World Petroleum Congress, Fifth.**—Early in June, 1959, at New York Coliseum, New York, U.S.A. Apply to the British National Committee, Institute of Petroleum, 26 Portland-place, London, W.1. Tel. LANgham 2250.

Management

Weekly Survey

Idealism and Technical Assistance

A number of basic thoughts were discussed by Mr. Alec Dickson, head of U.N.E.S.C.O. Technical Assistance Commission, in his paper to the British Association at Dublin under the title of " Idealism and Technical Assistance—Misgivings and Mistakings." He made a plea for this country's concentrating on quality and not quantity. It is some measure of the confusion in thinking when large sums are involved that it is necessary for some one to draw attention to the basic difference between aid and charity.

" Aid " or " assistance " carries with it the idea of a temporary giving on the part of the donor and the preservation intact of the dignity of the recipient. Under such circumstances there is present the idea of a stimulant to increased effort. If the recipient is to make best use of the aid, either to pay it back or make the fullest use of limited resources, help from outside must be allied to self-help.

These ideas have very real meaning for financial and technical assistance in underdeveloped countries. Flooding backward areas with money, equipment or technical advice has been shown to numb initiative and develop the attitude of the permanent pensioner. In some areas, according to Mr. Dickson, initiative and the spirit of adventure have been lost among those who have benefited at times from technical aid in the way of improved education.

The conclusion to be drawn is not that aid is a waste of time and resources in such territories, but that it should be applied economically and with the intent to stimulate (even if this decelerates the pace of development) rather than relying on vast resources to get quick results. This is not an argument for parsimony but for political economy.

* * *

Investment Comparisons

An article by Professor A. K. Cairncross in the latest issue of *Progress*, the house journal of Unilever, draws attention to the danger inherent in the popular exercise of comparing the rates of capital investment in this country and other countries in Western Europe. He points out that it is more important now to argue about the volume of public investment, how it is to be controlled and financed, and what the rate of savings by public authorities and nationalised industries should be, than to concentrate exclusively on investment by private industry.

Professor Cairncross is not complacent about the rate of investment in this country. It is true that his article points out the probability that comparisons with other countries which have been to the United Kingdom's disadvantage, have probably overlooked several very good reasons why, in recent years, capital formation in this country has been slower than elsewhere. He instances, for example, the more rapid growth of population on the Continent than here, with its attendant need for more houses and schools, and the need to remedy war-time devastation on a much bigger scale than here. He would focus attention on how to raise more capital in Britain and where to invest it, rather than encourage arguments about international comparisons of investment. He says " I should myself agree that a rather higher rate of investment in the United Kingdom is desirable; but I should rest this judgment much less on the high rates of investment in other countries than on evidence that Britain's need of capital is likely to increase, and that arrears have been accumulating in particular directions, notably roads and commercial buildings." Whichever way the argument is taken, the need remains for more factories and better roads.

* * *

Europe and the Steel Famine

An analysis has been published by the Iron and Steel Committee of O.E.E.C. called " The Iron and Steel Industry in Europe " which deals with the western European steel industry up to the middle of 1956, with certain information running to the end of last year. It points out that the index of crude steel production in western Europe is still higher than that for industrial production as a whole. In general, the steel famine throughout the world continues and the European steel industry reflects this shortage to a considerable extent.

A certain amount of concern is expressed about supplies of raw materials and the report points out that the high level of steel output has been achieved only by importing larger quantities of coking fines, scrap and ore from outside western Europe, especially from America. Capital investment has increased not only for renewing and extending plant but also for new units and the pattern is similar to the one in the United Kingdom, where basic iron and steel capacity is being enlarged to fit the rolling mills. Costs are rising and the possibility of raising output on the same cost basis as in recent years is now thought to be exhausted.

There has been a big increase in exports of steel to countries outside O.E.E.C. The main problems of the industry within O.E.E.C. are considered to be a reduction in the industry's dependence on raw materials from outside the area, improving the supply of manpower and an increase in prices to improve the attractiveness of steel as an investment. Overall, the picture in western Europe is very similar to the one for the United Kingdom.

* * *

Setting Up in Canada

Canada is attracting increasing interest from abroad as its industry potential increases. All types of concern are seeking to establish selling offices, branch factories and subsidiary companies. The Canadians are increasingly aware that British undertakings are looking for sites and are beginning to offer locations and amenities.

One such is the Whitby Industrial Commission in Ontario which has put out some attractive sales literature on the merits of its own township. It offers a town plan and a well presented brochure, setting out answers to the kind of questions any British company going to Canada would want to ask. It deals with the price of land, water and power, markets, materials, labour and services. It gives a list of industries already established, which is an exceedingly useful guide to companies seeking a location. It even goes so far as to suggest the kind of industries that might want to settle in the town.

This is a useful service for companies which have the whole vast populated belt of Canada to choose from and whose product does not demand a particular location near to its raw materials or market. This kind of service from Canada is of considerable value on this side of the Atlantic. Even if it does not enable a company here to choose an exact location, it narrows the field and enables executives in Britain to think in terms of amenities and services which are available.

* * *

The Executive Animal

A series of articles is running currently in one of the Sunday newspapers which shows the complex and sometimes contradictory forces at work in moulding the successful business executive. He is not always the aggressive and self-opiniated tycoon; he can be a pleasant shy man driven on to overcome a sense of inferiority. A paper recently published in the journal of the American Society of Naval Engineers has had something to say on this subject. The paper reads remarkably freshly, although it was delivered exactly 11 years ago by Mr. Lyle Spencer before the Industrial College of the Armed Forces of the United States.

Mr. Spencer pointed out that the motivating rewards of money can be over-emphasised. Although the wish to earn more money is an important motivating force, nearly all executives in top management look for the respect and affection of the president or chairman. The feeling of personal satisfaction in a job well done is also important. Most executive teams monitor their own conduct, administering their own rewards and penalties and the main problem in managing them is to plan, co-ordinate and guide their work. A good top executive is usually his own most critical judge and jury. In a survey made when the paper was written, most executives did not think that the majority of the critical incidents which they had remembered about themselves were known to anyone else in the organisation. Many good executives have a sneaking suspicion that they are not quite good enough for their job, and in consequence they need a continuing reassurance which they derive from a continuing accomplishment. Most senior executives would apparently appreciate franker discussion and more frequent systematic appraisal of their work by their seniors. It would appear that the " average " executive is no more an idea to conjure with than the tycoon of the cartoon.

* * *

Urban Land Use

An American professor, Mr. Ernest M. Fisher, reminded us, in a paper he read to the British Association at the meeting in Dublin, of the fact that traffic congestion was known in Roman times, and reported that Juvenal described how Julius Caesar forbade the Romans " after sunrise or before the tenth hour of the day to lead or drive any heavy wagon . . . " in the streets. Mr. Fisher, who is professor of Urban Land Economics at the Graduate School of Business, Columbia University, New York, suggests that some of the nonsensical developments of the past may be replaced by a more logical pattern, better fitted to provide for the changing needs of urban communities. There was a need to study " linkages "—the web of relationships among establishments—especially the movement of persons and goods among them, to provide a better understanding of the problems involved and of the total cost (including the social cost) of given patterns of land use.

Professor Fisher reviewed the very extensive literature on the subject and pleaded for concerted action by economists in a field where technological advances would make the problems even more complex than they were to-day. " The field," he said, " is wide open and the challenge pressing." One aspect of land planning on which Professor Fisher placed great emphasis, was its permanency. The results of decisions made to-day endure for generations, and what was done was hard to undo: " We are shaping urban land use patterns to-day that will shape the urban civilisation of to-morrow."

" Economic Aspects of Land Use Patterns " is a useful paper, if only because it shows that America has, in its heavily populated areas, precisely the problems we have in this country and has not been any more successful at solving them than we have been. There is an inherent conflict between to-day's need for a profitable enterprise and the needs of society in a decade, or five decades hence. The danger is that the thinking and planning for to-day does not and cannot anticipate the year 2000. Yet the buildings, and the roads, will remain for the cost of change is almost invariably greater than the evaluation of people's need for it, especially that of the private person.

Research and Development

FISH SOUNDING DEVELOPMENTS

Two new advances in echo-sounding techniques for the fishing fleets have been announced by Kelvin and Hughes (Marine) Limited, 99 Fenchurch-street, London, E.C.2—a new instrument for the midwater fishermen who practise ring-netting from small open boats, and a marked step forward in the apparatus available to the bottom-trawling fleets which makes it possible to distinguish clearly between fish lying on the sea-bed and the bottom itself.

"WHITE LINE" RECORDING

The latter development, known as "white line" recording, operates as follows. When there are no fish on the sea-bed, the bottom contour appears as a thin dark line of constant thickness, followed by a white space, as depicted on the left of the accompanying reproduction of a recorder chart. When fish are encountered on the sea-bed, the echoes received from them cause an increase in the thickness of the dark line, as may be seen towards the centre and right of the illustration. This chart also shows the appearance of the trace when the white-line facility is switched off for a short period; it will be seen that the fish echoes merge with the bottom echoes and cannot readily be distinguished. Large shoals are recorded as extensive dark patches, single fish appear as spikes protruding from the thin bottom contour line. Normal undulations in the sea-bed do not cause any thickening of the line.

"White line" recording is achieved by discriminating electronically between the strong echoes received from the sea-bed, which are used to open a gate in the amplifier circuit producing a white discontinuity on the chart, and the much weaker echoes from the fish, the strength of which is insufficient to open the gate.

"White line" recording not only gives a more positive indication of fish on the bottom; it also gives the trawler skipper some idea of the quantities, and allows him to regulate his towing time accordingly, resulting in greater efficiency and economy of the trawling operation.

OPEN-BOAT ECHO SOUNDER

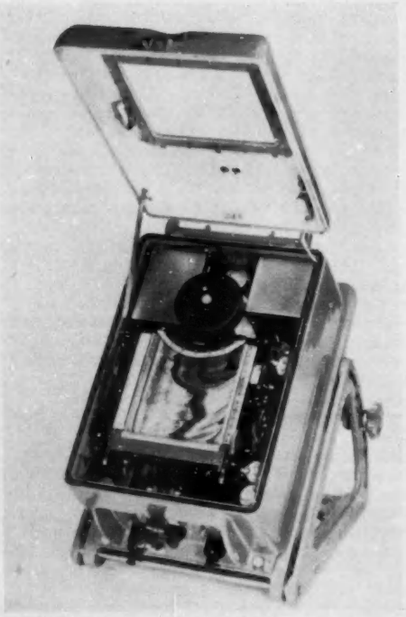
The other new echo-sounding development now entering the market is the MS30 echo sounder, low in cost and designed specially for use in small boats and "dories"—the open boats that operate the ring nets in mid-water trawling. Shown in the accompanying illustrations are the two units comprising the MS30—the small robust transmitting and receiving transducer, 6 lb. in weight, permanently polarised by the use of sintered ceramic magnets; and the portable recorder, weighing only 50 lb. and provided with a metal carrying handle and arranged with the controls all at the bottom of the case, where they are protected from damage by a shield cast integrally with the case. The recorder is watertight and has successfully withstood 24 hours of immersion in 12 ft. of water with no sign of leakage.

The chart, incorporating "white line" recording, shows the white line switched off for a short period, and illustrates the difficulty of distinguishing fish echoes merging with bottom echoes. In contrast, where the white line is switched on, the presence of fish is clearly indicated by the thickening of the black bottom contour line.

The recorder incorporates an automatic voltage controller, so that consistent performance is obtained despite fluctuating battery voltages, and the unit is correspondingly more reliable in service. Three paper speeds provide for economy in paper when navigating and effective fish detection when searching. Two transmission-pulse lengths enable the user to obtain optimum results in shallow and in deep water, and in different types of fishing.

Performance data are given in the table below.

	Basic scale, fathoms	Maximum scale, fathoms	Paper travel per minute
Standard	60	110	0·5/0·33/0·16 in.
Shallow water ..	30	55	1·0/0·66/0·33 in.
Deep water ..	120	220	0·25/0·16/0·08 in.



The MS30 echo-sounder recorder designed for small boats.

The transducer of the MS30 echo sounder is streamlined for securing to the bottom of the boat.

FISHING BOATS AND GAS-TURBINES

The development of gas-turbine propulsion for trawlers received a setback when the White Fish Authority were unable to offer sufficient finance to make possible the installation of a gas-turbine engine in a distant-water trawler. The applicants asked for help in the event of the engine proving a failure. The authority attempted to secure a Government grant, "in view of the importance of the development," out of the provision for research and experiment in the Sea Fish Industry Act. The request was turned down, "owing to the present economic position," and the authority offered a contribution of 25 per cent., subject to a maximum of £20,000, towards the net cost of replacement. This was not enough and the applicants dropped the scheme.

The information is contained in the sixth annual report of the White Fish Authority published last week. This gave details of the Authority's grants and loans scheme designed to provide an incentive for the rebuilding of near and middle-water vessels. Grants up to 25 per cent. of the cost of a new trawler, subject to a maximum of £30,000, and loans up to 60 per cent. are provided. At March 31, 137 grants had been made after 3 years' operation of the scheme.

★ ★ ★

SOLAR MAGNETOGRAPH

A new instrument for the detection of solar magnetic fields, the magnetograph, was described by Dr. D. W. Beggs and Dr. H. von Klüber in a paper, "A Solar Magnetograph," read to the British Association in Dublin. Although it is not yet fully completed, the basic unit was successfully tested some months ago at the Observatories, University of Cambridge. Its sensitivity is such that it is capable of registering fields as low as 1 gauss over narrow strips of the sun's surface about 100 seconds of arc long. There is in operation at the Mount Wilson Observatory, California, a similar magnetograph, the first instrument of this type, but the one at Cambridge is probably unique in Europe.

About fifty years ago, George Ellery Hale showed that by means of the Zeeman effect strong magnetic fields, some as large as 2,000 gauss, can always be associated with sunspots. Attempts to detect and measure fields over the rest of the disc were more inconclusive, the results of different observers often appearing contradictory. This was partly due to the fact that photographic methods are slow and inaccurate for fields below about 100 gauss, but observations with the magnetographs have shown that the field distribution across the sun is much more complex than once imagined. Earlier electronic methods were also somewhat inaccurate due to systematic errors arising from various sources.

The first real advance was made when Dr. H. W. Babcock of the Mount Wilson Observatory succeeded in ruling large plane gratings of outstanding quality. One of these gratings is installed in the 27 ft. spectrograph of the solar tunnel, Cambridge Observatories. Its measured resolving power is 600,000 and as a result the profiles of solar Fraunhofer lines are rendered without significant loss.

The method used in the magnetograph consists of placing two narrow slits on each wing of a line, λ5250·2, sensitive to the Zeeman effect. The light from the slits falls on two photomultipliers connected to a difference amplifier. The resulting signal is amplified by a selective-frequency amplifier, followed by a phase-sensitive detector and a recorder. The analyser of the circular polarisation on the wings of the Fraunhofer line is a crystal of ammonium dihydrogen phosphate in conjunction with a polaroid. The crystal is excited by means of a potential of 3,400 volts at 400 cycles per second. This type of analyser eliminates the systematic errors

formerly obtained by the use of rotating quarter-wave plates.

Observations with the instrument have confirmed the reported complexity of the solar magnetic field distribution. With short spectrograph slits 4 seconds of arc long, magnetic areas of up to about 100 gauss have been found in regions of the photosphere undisturbed in visible light.

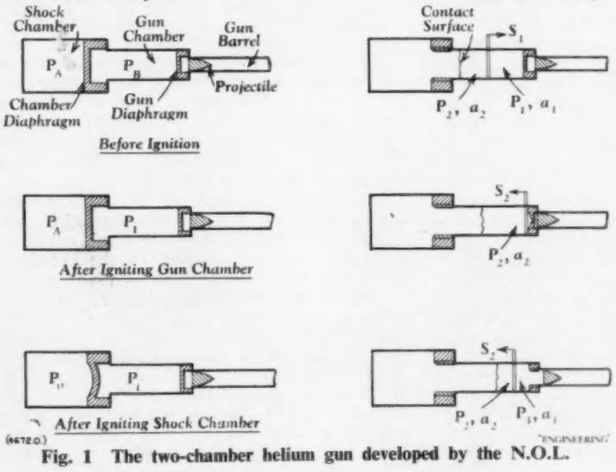
★ ★ ★

THE EXPERIMENTAL MATHEMATICIAN

The broad designation of physicists, say, as either theoretical or experimental, is familiar; but the experimental mathematician is a relatively new species. He may work at either pure or applied problems, and he may equip himself either with an electronic computer or with only pencil and paper; so that what distinguishes him from the theoretical mathematician is not so much his subject matter or his apparatus but his methods, which are observational and inductive rather than tautological and deductive. He infers his conclusions from experiments on numbers or other mathematical entities.

Attention to this distinction was drawn by Mr. J. M. Hammersley in a paper, " Percolation Processes," read to the B.A. in Dublin. Percolation processes provide a good example of the experimental mathematician at work. They lead to problems whose only known method of solution consists of a combination of mathematical theory with numerical experiments of the so-called Monte Carlo variety. Typical problems, which fall under the heading of percolation processes, arise in studying such things as the penetration of oil through sandstone strata and the proper spacing of fruit trees in orchards subject to infectious blight.

Percolation processes are concerned with the spread of a fluid through a medium. Here the words " fluid " and " medium " bear general interpretations: we may be thinking of solute diffusing through a solvent, or electrons migrating over an atomic lattice, or molecules penetrating a porous solid, or an epidemic striking through a school, or a rumour spreading through a community. To be a percolation process, the situation must satisfy two conditions: first, it must be appropriate to think of the spreading as governed, at least in part, by random phenomena; and second, it must be proper to think of the randomness as naturally ascribed to the medium rather than the fluid. When the second condition is not met, and the randomness is better ascribed to the fluid, the situation is called a diffusion process. Diffusion processes have been studied for a long time and are amenable to conventional mathematical theory; but percolation processes are a much tougher proposition and have not been studied for more than about three years.



(4472.0)

Fig. 1 The two-chamber helium gun developed by the N.O.L.

ABOVE MACH 10

RESEARCH TOOLS OF THE U.S. NAVAL ORDNANCE

The most exciting subject under discussion at the recent sixth Anglo-American Aeronautical Conference was hypersonic research for future missiles and, ultimately, aeroplanes—the facilities for solving the problems which arise from the very high air temperature involved. The boundary layer and the accompanying heat transfer are then the main subject of investigation. The air temperatures behind shock waves and within the boundary layer are higher than any solid material can withstand for any length of time. The air undergoes chemical changes, and changes due to vibration, dissociation, electronic excitement and ionisation.

In conventional long-running hypersonic wind tunnels for speeds around Mach 10, working at stagnation temperatures of 2,000 deg. F. and 150 atmospheres supply pressures, although the Mach and Reynolds numbers of the body at certain altitudes can be simulated very well, the temperature of the hypersonic boundary layers is far below those encountered in free flight. Therefore the effects of dissociation, electronic excitement and ionisation on flow pattern, friction and heat transfer cannot be studied.

These gas properties, at several thousand degrees, can be satisfactorily measured in shock tubes, but shock tubes are less satisfactory for testing model vehicles or components, because—apart from the fact that their running time is measured in milliseconds—the Mach number in the straight tubes cannot be much more than 2 because sonic speed is so high at these high temperatures. Attempts at raising Mach number without sacrificing temperature, by installing expansion nozzles at the end of the straight shock tube, are presenting difficulties, and by the time such shock tunnels have been developed as aerodynamic tools they will have become complicated gun-like facilities. Other promising " wind " producers for longer running times are multiple shock tubes and electric arc jets—but at present they are blow torches, rather than wind tunnels producing a clearly defined air stream, useful mainly for materials tests.

Free-flight scale-model tests can be carried out in pressurised firing ranges under controlled atmospheric conditions. In the United States Naval Ordnance Laboratory 300 ft. pressurised ballistic range, where the density can be varied from less than $\frac{1}{100}$ atm. to 6 atm., similarity in Mach number, Reynolds number, Prandtl number, and the correct temperature ratios produced by the true projectile velocities are automatically obtained, but the influence of surface curvature and roughness on boundary-layer conditions involves some difficulties. If an adequate hypersonic launcher is not available, relatively low-speed conventional guns can be fired into diatomic gases other than air, such as bromine or chlorine. Heavy monatomic gases can be used for very high-speed studies of electronic excitement and ionisation, without interference from vibration and dissociation. Such tests have been carried out at N.O.L. using a 0·30 calibre rifle and a bread-box size vacuum-tight " range."

Guns with expanding gases as propellants can be used to accelerate projectiles to hypersonic velocities. The pressure behind the projectile must be as high as possible and must drop only slowly with increasing projectile speed in the barrel, conditions that demand very high temperature and low molecular weight. Hydrogen or helium are suitable gases. One of the latest N.O.L. developments is a two-chamber helium gun (Fig. 1), in which the helium in a first combustion chamber is compressed and preheated by burning a mixture of hydrogen and oxygen, and is then further compressed by a shock produced by the rupture of a diaphragm of a second combustion chamber. N.O.L. are aiming at speeds of about 16,000 ft. per sec. with 40 mm. diameter projectiles fired in a 1,000 ft. pressurised range.

Force measurements in hypersonic tunnels are readily carried out by strain-gauging techniques. For measuring shock-speed in shock tubes and tunnels, a microwave interferometer has been used successfully. Most of the information from ballistic range tests is derived from shadow, schlieren or interferometer pictures (Fig. 2). Not yet in use, spectrographs could be used to analyse luminescence of the flying model for measuring heat transfer, and ballistic pendulums could provide quantitative information of ablation processes. Telemetering equipment for tiny models, which are accelerated up to one million *g*, requires much development. A new method being tried at N.O.L. comprises a simple resonance circuit within the model modulated by the change of resistance in a surface wire.

Materials can change their states at the high temperatures, heat-transfer and shear rates at the surface. The melting process on a projectile nose is therefore being studied (Fig. 3).

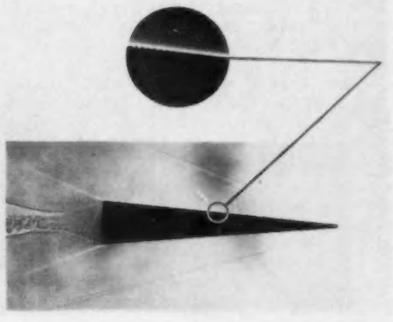


Fig. 2 Shadowgraph of boundary layer transition obtained on 40 mm. models fired in the pressurised range.

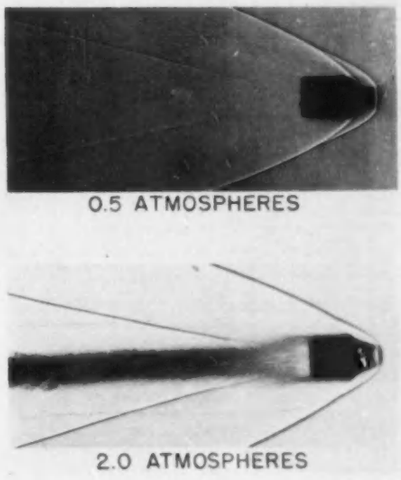


Fig. 3 A heat transfer test on a projectile with a melting metal nose in the pressurised range.

Book Reviews

FOUR CERTIFICATES TO EACH DEGREE

The Problem of Scientific and Technical Manpower in Western Europe, Canada and the United States. *Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris 16e, France.* (500 francs); and *H.M. Stationery Office, Kingsway, London, W.C.2.* (10*s.*)

Mehr Technik—mehr Ingenieure: Der Mangel an Maschinenbau-Ingenieuren. By DR. ING. H. J. STRÖER. *Verein Deutscher Maschinenbau-Anstalten E.V., Barckhausstrasse 18, Frankfurt-on-Main, Germany.* (No price given.)

Two recent investigations cover different aspects of the same problem, the world-wide shortage of engineers and scientists. While, however, the O.E.E.C. report concentrates on a broad statistical survey of the situation in all its member countries, the VDMA report concentrates on one particular aspect of the problem, the shortage of mechanical designers in Germany; on the other hand, it also contains a broad survey, including data on Russia.

Of the two reports, that of the VDMA, which is dealt with in detail below, is perhaps the more interesting, since a previous O.E.E.C. report and a number of papers have recently covered most of the same ground as the present O.E.E.C. report. Both investigations drive home how little is known of how men with technological educations are employed, how they ought to be employed, or how many such men are needed. On the answer to these questions must be based Britain's educational policy. The implicit theme of the O.E.E.C. report is that Russia is pursuing the right policy, and that other nations face losing the cold war for lack of engineers to advance rapidly enough either their own standard of living or that of the backward countries. Even if enough engineers are being educated, they may be hamstrung for lack of technicians.

The VDMA, the Association of German Machinery Manufacturers, has published this fascinating investigation into the number of mechanical engineers, both graduate and of Higher National Certificate standing, actually employed in industry in Germany, the estimated shortage of such engineers, and the capacity of the German technical universities and technical colleges to supply the estimated requirements. The book is packed with useful figures and estimates, many of them new, and, in addition, it contains many data on conditions in other countries. In this respect, the author accords Great Britain a word of praise for what she is doing in the furtherance of engineering education, which may astonish some of the critics at home. Whereas the figures themselves are on the whole superficially probable, the conclusions which are drawn from them appear to a certain extent to be influenced by emotional or political feelings; or possibly, to be more generous, by allowing the conclusions to be influenced by further unpublished, but quite possibly correct, estimates of future requirements. On the face of things, however, certain conclusions in the book appear to run directly contrary to the data published in it.

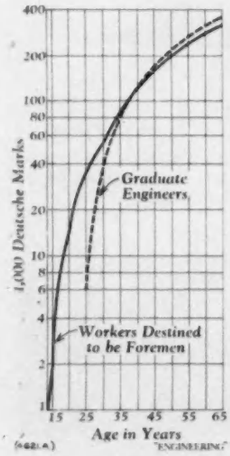


Fig. 1 (left) Comparison of the total income received up to any age by an average graduate engineer and an average foreman in VDMA firms, at current salaries. (Note: 11 DM roughly equal £1.)

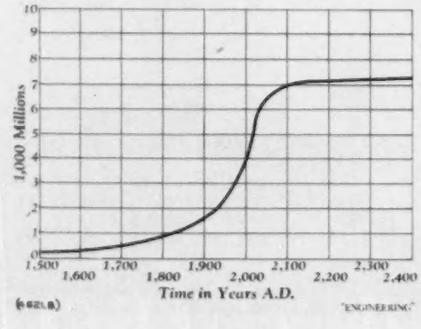


Fig. 2 (below) Estimated increase in world population.

The field for misunderstanding is almost limitless whenever an attempt is made to compare the educational systems of two countries, and after observing the mistakes of the author of this book when he tries to interpret what Great Britain does, any reviewer may be forgiven if he feels nervous of committing worse solecisms himself. However, to avoid confusion (even if it arouses ire), the reviewer of these books proposes to refer to *Diplom-Ingenieure* as graduates, and to *Ingenieure* as Higher National Certificate men. The really fascinating parts of this publication, however, are those on which discussion appears to be universal in Western Europe and America at present. Thus, an investigation in the VDMA of the *average* earnings of graduate engineers and of the earnings of men who rise to be foremen shows that, by the time that they are 65, their total earnings, less the amount spent on their education by their parents, are equal. The accompanying graph, reproduced from the report (Fig. 1), shows the gross earnings uncorrected for the cost of education.

Again, German industry is troubled by the fact that graduates do not want to become designers in adequate numbers, in spite of the fact that after their first two years at the university, all their instruction is received by way of design. Many reasons for this tendency are discussed, especially the belief that design is less well paid than are sales and production; but the notion is shown to be untrue in the German firms investigated, although it is believed in by the graduates concerned. The discussion of this problem is more enlightened than is usual, but it still does not come to grips with the real trouble, namely, that the specialisation of function in large firms has reduced the sense of responsibility of the designer by reducing his contacts with both his customers and his suppliers in the outside world and with manufacture nearer at hand. All too often mechanical design is a poor relation of the stress or projects office.

The problem of the relationship of numbers of graduates to H.N.C. engineers is discussed at length, and the conclusion is reached that a ratio of about 1 : 4 is required. In this respect, the report points out that while Germany lacks H.N.C. men, Britain lacks graduates most acutely. The question, too, of the wasteful use of technical ability on the preparation in great detail of tenders, of which not more than 10 per cent. have any chance of success, and also of its waste in other directions is considered. With regard to the future, too little is said, but if the graph predicting increases in world population (Fig. 2) were even vaguely correct, it would provide the text for pages of comment. The most obvious is that if the increase of population is to enjoy an adequate standard of life, enormous numbers of engineers will be needed by the countries which are now under-developed. At present, apparently only Russia is educating engineers in sufficient numbers to supply the demand: let us hope that that flag will not follow trade.

Further studies of this sort would be invaluable, both in this country and in Germany. The author has added a useful bibliography, which mentions among other papers one which will shortly appear on the estimated effect of automation on the demand for engineers. (Can some psychologist say what proportion of the population is potentially capable of satisfying the demand?)

These two volumes are likely to become standard sources for the statistics needed both by those people who are trying to solve the problems under discussion and by those engaged in political polemics. The books will prove invaluable to both classes, but their figures need handling with caution.

FLUID IMPACT

Waterhammer Analysis. By JOHN PARMAKIAN. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (45*s.*)

The pressure produced by stopping the flow of water in a pipe has been utilised in the hydraulic ram for many years, but no serious study of the phenomenon known as waterhammer or pressure surges was attempted until the beginning of the present century. Joukowski, in Russia, and Allievi, in Italy, laid the foundations by experiments and theoretical analysis, and by the 1920's the subject had begun to arouse widespread interest among engineers in Central Europe who were developing the hydro-electric resources of that area. The result was that most of the original contributions were published in either German or French, so that the English-speaking student finds himself restricted to a relatively small number of papers, most of which deal in the main with experimental investigations.

The interest shown by American engineers in this field has led to the symposia organised by the American Society of Mechanical Engineers in 1933 and 1937, and after the war the American Bureau of Reclamation began an intensive study of waterhammer phenomena and methods of analysis. The author of the book under review is in charge of engineering analysis in the design section of the Bureau and has been able to draw on the results of original research by several of his colleagues, among them C. C. Crawford and W. E. Evans. The book is based on a lecture course organised by the University of Colorado and represents the only text-book in the English language devoted exclusively to pressure surges in water-pump and turbine systems.

The initial chapters are devoted to the derivation of the conventional expressions for waterhammer in rigid and elastic liquid columns, followed by an introduction to the graphical method of waterhammer analysis, which is then utilised throughout the remainder of the book. Most of the standard problems are dealt with, among them uniform and non-uniform turbine-gate closure, power failure in pump discharge lines, the effect of friction losses, and various types of compound systems. There is a full discussion on the use of the complete pump characteristic for analysing the performance of the pump under transient conditions, and this

section includes several useful graphs for estimating extreme pressures and other factors during pump shut-down. The last two chapters deal briefly with surge tanks and air vessels.

A special feature of the book is the large number of "problems" (with answers) which are based on practical engineering experience and which cover every subject discussed. They will prove particularly useful to the many engineers who (like the reviewer) have to acquire their knowledge of waterhammer analysis from a book without assistance from anyone experienced in this work.

It is not unexpected that this book, like all text-books addressed mainly to students, presents the subject by means of simple statements and sweeping generalisations without mentioning those points which require a more detailed analysis. The formulae for the surge velocity in complex pipes (wood stave, reinforced concrete, lined tunnels, etc.) are presented without experimental or theoretical justification. The phenomena which accompany the separation of a water column have had to be oversimplified. True to its title, the book deals only with surges in water systems, and it is regrettable that the author has not found space to mention the special problems arising in other cases such as crude-oil pipelines, oil-hydraulic controls, or fuel injection systems.

The book provides a very satisfactory introduction to the subject of pressure surges and it is to be hoped that it will stimulate the establishment of undergraduate courses in this highly interesting and, in the past, rather neglected field.

★ ★ ★

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Fine Grinding. FOLLSAIN-WYCLIFFE FOUNDRIES LTD., Lutterworth, near Rugby. "Pulmac" pulverisers for fine grinding. The machine, available in four sizes, grinds by a combination of rotor action, beating of the material particles against each other, centrifugal force and induced air. It can be adjusted for various size-reductions, and is easily dismantled for cleaning. Illustrated brochure.

Grinding Wheel Dressing. ENGINEERING DIAMONDS LTD., 26 Warwick-row, Coventry. Precision dressing slide unit, consisting of a lever-operated slide with three stations for the diamond tool, one at each side and one at the top. It can be set up in many different ways for dressing angular faces. Illustrated leaflet.

Boring Tool Holder. J.C.J. ENGINEERING, Southam, Leamington Spa. J.C.J. precision offset boring head, with taper or parallel shank. Boring capacity zero to 6 in. diameter. Tool adjusted by a screw, with dial indication graduated to 0·001 in., or with vernier reading to 0·0001 in. Illustrated leaflet.

Induction Motors. LAURENCE SCOTT AND ELECTROMOTORS LTD., Norwich. Guide to the application of squirrel-cage and "Trislot" motors includes notes on methods of starting and charts of performance for these motors under different conditions.

Smoke Density Equipment. RADIOVISOR PARENT LTD., Stanhope Works, High Path, London, S.W.19. Detection and recording units for smoke density. Types for measuring actual density or giving warning when a certain density is exceeded. Illustrated folder.

Mining Equipment. WESTINGHOUSE BRAKE AND SIGNAL CO. LTD., 82 York-way, King's Cross, London, N.1. Comprehensive catalogue of mining equipment including decking, rams, tub stops, retarders, rail points, air-lock doors and car handling gear.

"Safeguard" Wiring System. CLAYTON SAFEGUARD LTD., East Union-street, Liverpool 3. Enclosed conductor system for the protection of unguarded wires in factories where the headroom is low. For the supply of power to cranes, hoists and portable tools. Illustrated leaflet.

Rope Splicing. BRITISH ROPES LTD., Doncaster. "How to Make a Long Splice." Booklet giving detailed instructions step by step, for splicing wire ropes. Each step is illustrated by a diagram. Recommended lengths for long splices, according to rope size, are given in tabular form.

Control Station. BAILEY METERS AND CONTROLS LTD., 153 Moorgate, London, E.C.2. Self-contained remote-control switch unit for two independent circuits with indicating lamp for each. Leaflet E75–4.

Hydraulic Power Units. E. P. BARRUS (CONCESSIONAIRES) LTD., 12–16 Brunel-road, Acton, London, W.3. "PortoPower" hydraulic equipment for all general purpose work. Brochure "Elephant at your Elbow" suggests some uses.

Cast-Iron Blowers. LONDON FAN AND MOTOR CO. LTD., 27 Brecknock-road, London, N.7. "Breeza" cast-iron blowers, five sizes up to 1,600 cub. ft. per min. at 1,425 r.p.m. Leaflet gives dimensions and performance curves.

Air Hose Couplings. B.E.N. PATENTS LTD., P.O. Box No. 10, High Wycombe, Bucks. "Instantair" couplings for air hoses with working pressures up to 10,000 lb. per sq. in. Made in two sizes for $\frac{1}{4}$ in. or $\frac{3}{8}$ in. gas threads. Leaflet.

Heater-Charger. POWER FREQUENCY HEATING LTD., Alexandra-road, Hounslow, Middx. "Peregrine" combined engine heater and battery charger, in which the charging current is used to heat the engine oil. Illustrated leaflet gives details

On the Shelf

By Frank H. Smith

An international book exhibition is to be held in Tokyo from January 14 to 19 next year. It is intended to exhibit works according to their country of origin, subdivided into certain categories, one of which is civil engineering and public works and another is technical engineering. Further particulars are obtainable from The A. P. Wales Organisation, 36-38 Southampton-Street, London, W.C.2.

A new annual collection of statistics has made its bow. This one is very specialist and is called *World Air Transport Statistics*. The issuing house is the International Air Transport Association, 1060 University-street, Montreal 3, Canada, and the price is 50 cents. The publication replaces the tables that used to be published in the *IATA Bulletin*, now no longer published.

I am a little late in noticing this but the appropriate H.M.S.O. circular (the July issue) has only just reached me. There is a new Ministry of Health publication on *The Rehabilitation of Amputees*. If Sir Alan Herbert reads this I invite his comments on the last word in this title.

On May 31, I mentioned the projected change in the form of the *Proceedings* of the Institution of Civil Engineers. The first of the new numbers has now appeared. Henceforward, papers to be delivered will be printed in the *Proceedings* a month ahead (which anticipates a rigid disciplining of authors) and about six months later the discussion will be printed. This will save the old system of preprints (although they will still be available at 2*s*. to members and 4*s*. to non-members), but it will have the disadvantage, as I see it, of papers and their discussions being split in the bound volume. On the other hand, every member will be able to read a paper before attending a meeting (which can lead to some awkward non-spontaneous questions at the discussion). Another point I do not favour in the new *Proceedings* is the system of paginating the news section with a prefix N and the papers section with no prefix—both sections being numbered independently. What has happened is that pages N1, 2, 3 and 4 include the title page and the index for the papers section. Anybody wishing to split them for binding may well become confused. We shall have to wait and see if the final index to the volume is in two parts.

I like the "Definition of the Professional Engineer" which is printed in this number. It says, among other things, that "his education will have been such as to make him capable of closely and continuously following all progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating this information and applying it independently." The man who wrote that has shares in a firm of abstracts publishers and interests in a rapid reading course, I should imagine.

Those who collect bibliographies in the same way that philatelists collect stamps may be interested to know of a list on "Ingenieria" issued as a *Boletin del Centro de Documentacion Cientifica y Technica de Mexico*. It is dated February, 1957, and is No. 2 of volume VI and seems to cover a very broad field. It is assumed that this is one of a series, which probably accounts for the absence of any foreword or other explanatory matter. It would seem to cover the literature for 1956 only, but the coverage is world-wide. Titles are given in Spanish, followed by that of the original tongue.

Current Affairs Limited, 319 High Holborn, London, W.C.1, have published (at 8*s*. 6*d*., postage 3*d*.) a neat and useful little book entitled *The Year's 16 mm. Films: 1956*. This is the seventh such volume and it is, primarily, a collection of reviews taken from the *Film User*. The book is divided into three groups, namely, factual, entertainment features and entertainment shorts. Readers of this paper are likely to be interested only in the first category and this is indexed in the front of the book in universal decimal classification order. There is also a title index at the end of the book. Another useful feature is a directory of distributors with their addresses. Each review is coded so that such important items as running time, where the film can be obtained, etc., can be ascertained. Readers to whom this annual is news may not know of *Scientific Film Review* (164 Shaftesbury-avenue, London, W.C.2, 21*s*. per annum) which is the journal of the Scientific Film Association.

Here is a true little story (only the names have been changed to protect the innocent !). A firm of booksellers telephoned me to ask if I had ever heard of certain Continental conference *Proceedings*. They had had a request from their client—Messrs. Whatsit—for these papers and they had no idea where they were to be obtained. I happen to know Whatsit's librarian and rang him to ask where he had got the reference. One of his colleagues had seen it in the *Air Special* and had asked him to get it. I looked up my own copy of the *Air Special* and there, at the end of the paper quoted, was a note to the effect that "The Proceedings from which this paper was taken were of the umpteenth Conference on Flying Soup-Plates. Further particulars may be obtained from the Société, at 6 rue de ma Tante, Paris XV." All of which leads me to my point. Had my friend the librarian insisted on seeing the article from which the reference was taken, much abortive searching would have been saved by the poor bookseller (who covers many lines other than flying soup plates). It does not matter about *my* telephone calls and time-spending. It is what I am here for.

A little trouble at the source
May save a lot, way up the course.

Anon.

I am, I fear, one of those neurotics who get furious when I cannot bend the telephone to my will. Never again. I have just seen an article (treatise would be a better word) in *Philips Telecommunication Review*, for August, by J. W. Cohen. It is called "Basic Problems of Telephone-Traffic Theory and the Influence of Repeated Calls." There are 50 pages of it, of which about 80 per cent. are mathematical symbols. Next time I pass one of those little canvas shelters over a manhole I will take off my hat to the man who is there knitting the multi-coloured wires.

Production

PRESS TOOLS FROM PLASTICS

EPOXIDE RESINS HAVE MANY USES

Plastics, and in particular the more recently-introduced epoxide resins, offer many advantages for the production of tools used in engineering, foundry work and sheet metal fabricating. Plastics tools can be produced quickly to a high degree of accuracy from simple wood, metal or plaster moulds, models or patterns. The epoxide resins harden without the application of heat or pressure, and can be used for laminating or for casting in bulk. The cured products are tough, hard wearing and very stable dimensionally. They are being used successfully for the production of duplicate models, checking and assembly fixtures, pantograph and copy-milling models, foundry patterns and core boxes, metal-forming tools for short runs, and other tools of similar types.

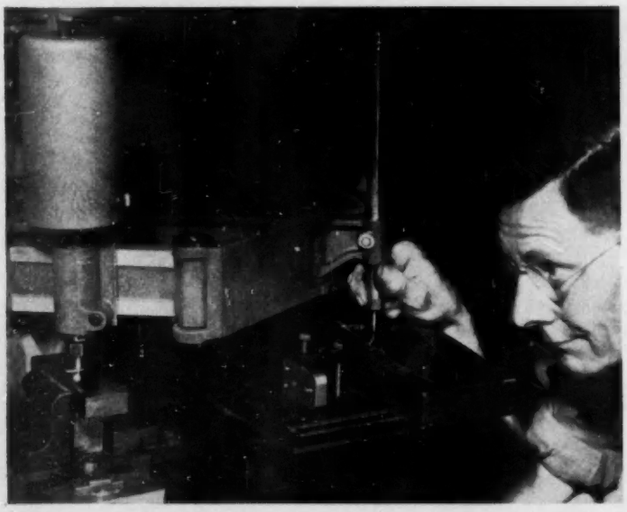


Fig. 1 (left) The very accurate, hard wearing qualities of Bakelite epoxide resins make them ideal for casting tools, patterns or models, such as this pantograph model.

Up to the present, comparatively little information has been generally available on the making of tools from epoxide resins, and as their use is expanding rapidly, Bakelite Limited, Grosvenor-gardens, London, S.W.1, have prepared detailed instructions for producing tools by four different methods.*

Liquid epoxide resins are hardened or cured by chemically combining them with selected materials known as hardeners. These combine with the resins to form an integral part of the hardened structure, and therefore have a pronounced effect on its physical properties. In addition, the hardener has a marked influence on the curing rates and handling characteristics of the resin/hardener mixture. The chemical reaction which takes place between the epoxide resin and the hardener is exothermic, that is, it be kept low to minimise the shrinkage caused by thermal contraction. The rise in temperature is governed by the reactivity of the hardener used, and the bulk of the material involved, so when the bulk is large, hardeners of low reactivity are used; for smaller bulks, where part of the heat is lost, more reactive hardeners are suitable. For thin films and laminates only the most vigorous hardeners can be used.

FOUR METHODS

Four different methods are being used for producing tools from epoxide resins, the most suitable method for any particular application, depending on the size and intricacy of the tool involved, the economics of production, and the mechanical properties required. The methods are: single-stage gravity casting for small, lightly-stressed tools of intricate contour; two-stage casting for tools of the same type which are too large for the single-stage process; laminating, for large, lightly-loaded tools of relatively simple contour; laminating combined with gravity casting for large and small highly-stressed tools, particularly those used for metal forming.

Resins and hardeners are available in grades to suit the particular application. Certain other materials are also needed for tool production; they are all easily obtainable. Almost any finely-ground mineral can be used as a filler, the choice depending on economics and the properties desired in the finished product. Slate powder is the most suitable general-purpose filler, being relatively cheap and giving good wear and abrasion resisting properties. A disadvantage is that tipped tools are needed when machining slate-filled resins. Calcium carbonate gives easier machining qualities than slate, and a light-coloured product instead of a dark brown one, but its use involves the sacrifice of some wear resistance. Very coarse, dry sand is used in the heavily-filled materials which form the cores of large castings. If thermal conductivity should be desirable, a substantial improvement can be obtained by using aluminium powder as the filler; this also causes some loss of wear resistance. An addition of 1 to 2 per cent. of Aerosil as a filler makes the mixture thixotropic and this is of value when producing glass-reinforced laminates which are inclined towards the vertical, as it reduces any tendency for the resin to drain. Finally, there is the question of reinforcing material. Any of the woven glass fabrics now available are suitable.

The basis of tool production with epoxide resins is an accurate model, mould or pattern, which can be in wood, metal or plaster. The model must have a fine surface, as the reproduction from model to casting is extremely fine and searching, and any imperfections in the model will be reproduced faithfully in the product. Epoxide resins have excellent powers of adhesion to many different materials, and release agents must be applied to the model surface before casting the resin. Materials having a porous surface must first be coated with a sealing medium of which there are several available to suit different materials. This treatment is followed by two or three coats of hard wax polish, or by a coat of a special silicone or other release agent. The model is then ready for use.

Single-stage casting is simple, but it can only be used for tools up to a maximum thickness of about 6 in. Above this size the two-stage process is used. There are two basic casting methods, room temperature curing and post curing; the latter involves a subsequent heating at 50 deg. C. for some hours, and gives optimum hardness. In either case the casting process is the same. The filler and resin are first mixed mechanically and the hardener is then added, mixing continuing for another 10 to 15 minutes, the materials being proportioned by weight, in accordance with the makers' recommendations. When the hardener is added, the mixture starts curing, and its working life as a liquid may be from 1 to 8 hours. Pouring should be done as soon as possible, while the viscosity of the mixture is at its minimum. In curing, the material shrinks slightly and provision for this shrinkage can be made in one of two ways. A slight excess in thickness can be cast, and the casting can be machined back to the required line, or alternatively the mould can be closed, and a head of resin can be applied, with risers.

For two-stage casting the mixing is similar to that described above, but coarse sand is used as the filler for the first stage, or core casting. The core is then faced with $\frac{1}{8}$ in. or $\frac{1}{4}$ in. of material similar to that used in single-stage work. Production of a two-stage casting is a more lengthy and involved process than single-stage casting, as it is necessary to make provision for mounting the finished product while the core is being cast, since it is not possible, owing to the abrasive nature of the filler, to machine through the thin outer casing into the core. The general principles involved are, however, basically the same in both processes, and detailed instructions are provided.

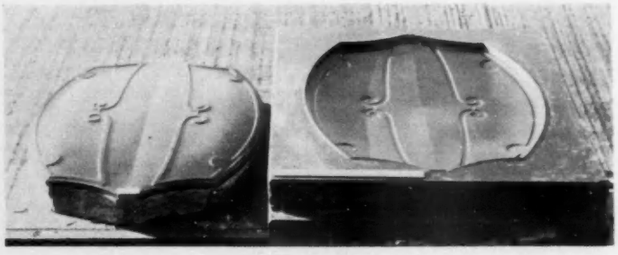


Fig. 2 For highly-stressed tools the resins are laminated and backed with cast material. These press tools are for forming 22 s.w.g. mild steel.

LAMINATING

Simple laminating provides tools of minimum weight with optimum stability and dimensional accuracy. Tools made by this process are usually reinforced and supported at the back by a tubular "egg-crate" type of structure, which may be of metal or any other suitable material, according to circumstances. The basic method of construction involves a mould or pattern, just as in the case of casting, the mould being produced to the same standards. A surface coating resin mixture is first applied to the mould surface by brush, the thickness being about $\frac{1}{32}$ in. Laminating resin mixture is then applied, and a layer of woven glass cloth is smoothed into the resin with a brush, care being taken to eliminate all wrinkles and entrapped air. Further coats of resin and glass cloth are then applied until the required thickness, usually at least $\frac{1}{8}$ in., has been built up.

For highly-stressed tools, laminating is combined with gravity casting. A lamination is first prepared by the method described. This will form the working face of the tool. Casting resin, heavily loaded with coarse filler, is then poured on to the back of the lamination, to build the tool up to the required height. Provision is made during casting for fixing the tool, as the cast material is not machinable. This can be done in several ways, the simplest being to bond a roughly-cut heavy metal plate into the back of the tool.

* Advance information sheet E 18.

Design

EQUIVALENT CIRCUITS AND THEIR APPLICATION TO INDUCTION MOTORS*

By D. J. Rowley, B.SC. (ENG.)

Summary.—The part that the equivalent circuit plays in electrical theory and practice is briefly indicated, and is followed by consideration of the advantages and disadvantages resulting from its use. The equivalent circuit for an induction motor is then given, and some of its shortcomings are mentioned. In particular, an experiment is described in which an attempt was made to explain the performance of a small squirrel-cage induction motor in terms of a simple equivalent circuit. This attempt met with very limited success, for reasons that are suggested.

An equivalent circuit is a means of representing a physical structure—e.g., an electrical component or machine—by " elements " which behave in a simple way. Examples include the " linear passive elements" of resistance R (where $V = IR$), capacitance $C\left(I = C\frac{dV}{dt}\right)$ and inductance $L\left(E = -L\frac{dI}{dt}\right)$, and also mutual inductance, with the " ideal transformer " as the special case of a mutual inductance with complete magnetic coupling. Others include rectifiers, " constant-current " and " constant-voltage " generators, and amplifiers.

A great many pieces of electrical equipment can be represented fairly accurately either by a single element or by a simple combination; this renders them, first, easy to understand, since they can be visualised more readily and, second, easy to handle mathematically—linear networks can be solved by highly developed and " streamlined " methods.

All new electrical developments or inventions tend to acquire equivalent circuits more or less rapidly. The concepts of capacitance and inductance enable electrostatic and electro-magnetic phenomena, both qualitative and quantitative, to be taught readily to secondary school students. Radio-wave propagation is explained using " transmission-line analogies " and the ideas of " wave impedance." Among microwave valves, the magnetron is often explained as an a.c. generator connected to a network of resonant circuits. The transistor, a device using complex semi-conductor effects, is represented by a current generator and a simple combination of resistors. These artifices make them easier to be understood and more readily applied. Indeed, a number of cases can be cited where a discovery or development was held up for years because the investigators were not " equivalent circuit minded "—in rather the same way as the progress of arithmetic was delayed for many centuries for want of the cipher, zero, a figure of value really only as an aid to a mental process. Again, for example, Fleming's discovery that a two-electrode valve could be used as a detector in a radio receiver was in essence a realisation that the Edison effect (which had been known for a long time) enabled a valve to act as a rectifier element.

However, there are pitfalls into which one can be led by an indiscriminate use of equivalent circuits. If they are rendered invalid by false assumptions, it is not easy to see through the assumptions to what is actually happening. Furthermore, certain components which are normally linear are often made use of in practice out of their linear ranges—e.g., valves in class-C amplifiers, or inductors in magnetic amplifiers. If an electrical system cannot be explained using a circuit which appears at first sight to be suitable, there may be a fundamental weakness in the theory involved (such as had to be remedied for circuits in which radiation occurred, or to explain for the first time the behaviour of transmission lines comparable in length to the wavelength of the current flowing), or there may be an error in the assumptions which requires the equivalent circuit to be modified or abandoned. A vivid instance of this is given by the power transformer, which can be represented in normal operation by two magnetically linked windings. When the transformer is struck by a lightning surge, this representation is totally inadequate, and in fact the voltage distribution can be explained accurately only if the windings are deleted altogether and replaced by their inter-turn and earth capacitances.

* Paper read before Section G of the British Association at Dublin, on Monday, September 9, 1957.

INDUCTION MOTORS

In most textbooks, the impression is given that the induction motor can be explained without serious error by a straightforward circuit. This is true only for medium and large machines. In the following section, a résumé is given of some of the limitations

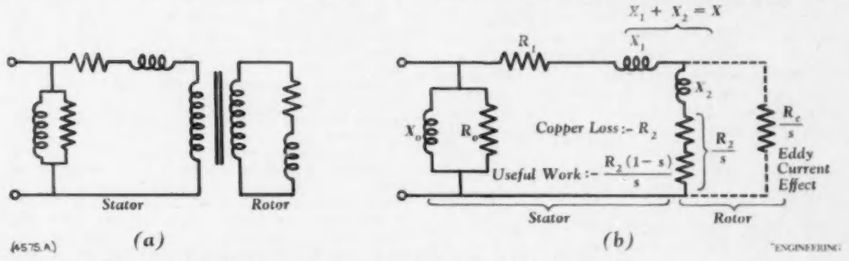


Fig. 1 Equivalent circuits for one phase of an induction motor.

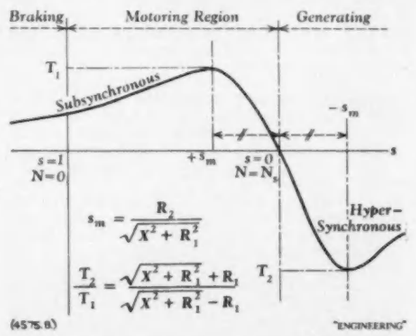
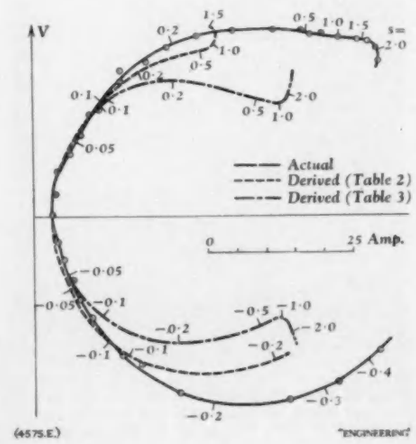


Fig. 2 Torque curve for a single-cage induction motor ($R_e = 0$).



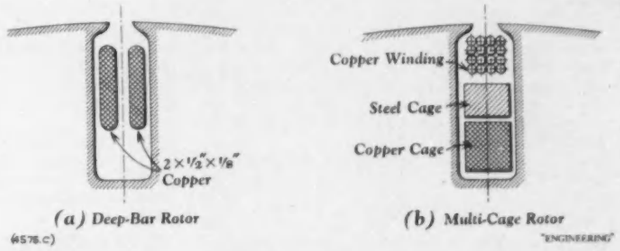


Fig. 3 (right) Slot sections: (a) deep-bar rotor; (b) multiple-cage rotor.

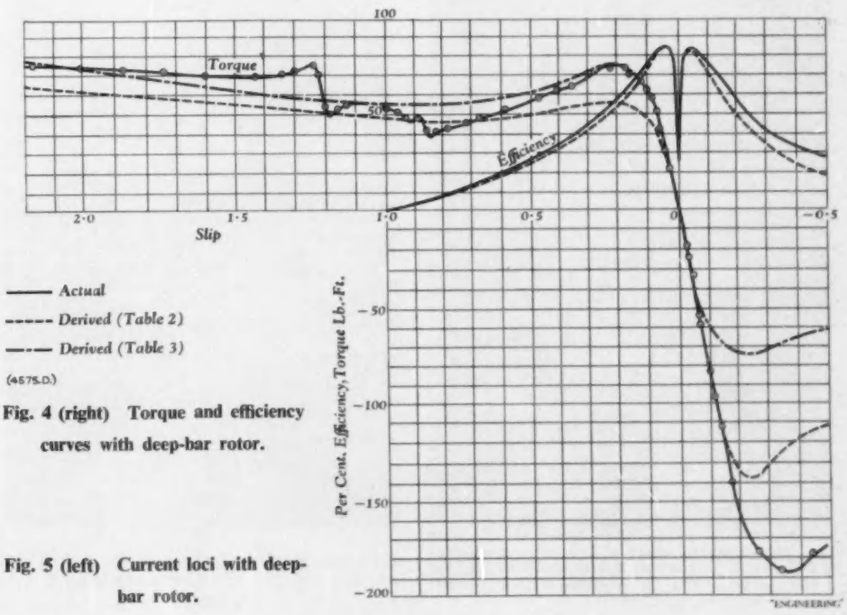


Fig. 4 (right) Torque and efficiency curves with deep-bar rotor.

Fig. 5 (left) Current loci with deep-bar rotor.

Continuing **Design**

of the accepted induction-motor equivalent circuit, and later they are related to actual torque curves and current loci taken on a small (5 h.p.) squirrel-cage motor to show the source and magnitude of the discrepancies between theory and practice.

For the reasons given above an equivalent circuit is a valuable aid in the design of induction motors and the calculation of their performance. Since the flux pattern in an induction motor is similar to that in a transformer, its equivalent circuit is also similar, and is given in Fig. 1. (The detailed development can be found in any textbook on the subject.) The main point of variation is that the secondary (rotor) resistance referred to the primary depends on the motor speed, N, and is given by $\frac{R_2}{S}$ where S (the "slip") $= \left(\frac{N_s - N}{N_s}\right)$, N_s being the synchronous speed of the machine, and R_2 being the rotor standstill resistance referred to the primary. The rotor resistance can be regarded as split into two parts, as shown in Fig. 1, representing the rotor copper loss and the power converted into useful work. X_2 is the referred rotor reactance, R_1 and X_1 the stator resistance and leakage reactance, and X_0 and R_0 the magnetising impedance. (R_e can be added to represent the effect of eddy currents flowing in the rotor laminations.) A rotor with two or more cages can be represented by placing two or more rotor circuits in parallel.

The ratios between the circuit components of a given single-cage motor can be worked out with the aid of its torque/slip curve as shown in Fig. 2, and their absolute value determined from current readings. For a double or multiple-cage motor, the task is more involved; each cage will have an influence on the torque/slip curve, and the current locus will no longer be circular.

The classical derivation of the induction-motor equivalent circuit assumes at least the following:—

1. That the "transformer analogy" is accurate. This is not altogether true; leakage effects, for example, are far more complicated in a motor than in a static transformer.

2. That all the field and current distributions are sinusoidal in space, so that simple a.c. theory can be applied. In fact, the field distribution depends upon the conductor spacing and arrangements, modified by the presence of slots in rotor and stator surfaces, and harmonic fields are generated which affect the motor torque curve.

3. That all the magnetic materials employed are linear in their characteristics. This again is not true; the iron in the teeth is normally at fairly high flux density.

4. That eddy-current effects in the iron, and skin-effects in the conductors, are negligible. The magnetic losses in a motor are difficult to predict, and eddy-currents flowing in the iron will affect both the current input and the torque of the machine. The skin-effect in the conductors, enhanced by the presence of iron teeth whose permeability is continuously changing with flux density, can cause large variations in effective resistance.

5. That the supply is balanced in magnitude and phase. Any supply unbalance will set up reverse torques, ignored by the simple circuit.

It may also be noted that the presence of teeth can prevent a motor starting (magnetic locking) and that hysteresis in the iron may cause a motor to run at synchronous speed at light loads.

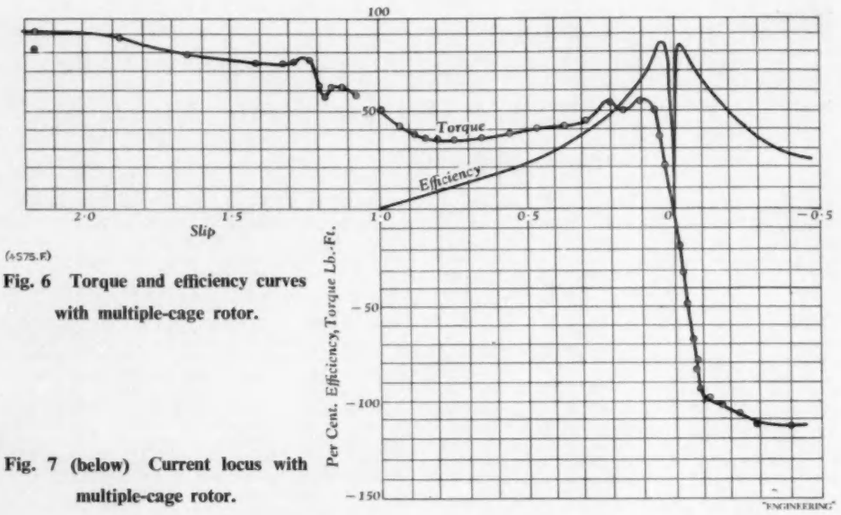
MOTOR TESTS

In order to assess the importance of these limitations of the theoretical circuit, tests were carried out on the motor described below, and two alternative circuits were derived from the torque curves and current loci obtained in the tests. Torque and efficiency curves and current loci were then recalculated from these circuits and compared with the tests.

Apparatus and test details

Motor : Rating: 5 h.p. at 230 volts.
Stator: 4 pole, 3-phase delta connected.
Size: Rotor active surface 9 in. dia. by by 4 in. long.
Rotors: Two alternative squirrel-cage rotors, with slot sections as in Fig. 3.

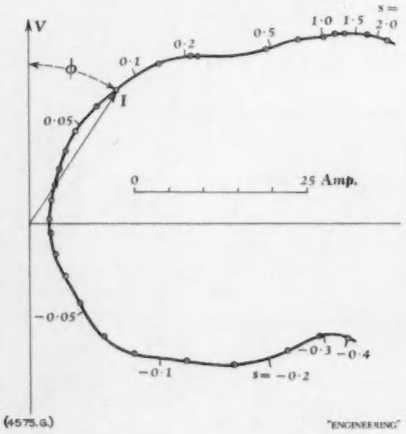
Tests: The motor was tested over a wide speed range with both rotors fitted in turn, and the motor-supply voltage was chosen at all speeds to prevent excessive current being taken. All torque and current readings were "normalised" to 230 volts (i.e., the equivalent values at 230 volts were calculated) and the torque curves have been corrected for friction errors. The current readings represent the load on one delta phase.



(4575.F)

Fig. 6 Torque and efficiency curves with multiple-cage rotor.

Fig. 7 (below) Current locus with multiple-cage rotor.



(4575.G)

TABLE I.—*Standstill Readings*

Voltage Volts	Actual current Amperes	Normalised current Amperes	Phase angle Deg.	Normalised torque Lb.-ft.
21·0	4·56	50·0	60·5	53
28·5	6·26	50·5	60·8	49
43·8	9·89	51·9	60·8	48·5
60·9	13·76	52·0	60·5	50

The results obtained are shown in Figs. 4 to 7 and also in Table I.

Calculation of Equivalent Circuits

Fig. 4 shows that, with increasing slip, the torque rises to a maximum, falls, and then rather unexpectedly rises again steadily. This was assumed to be due partly to magnetic drag caused by eddy currents flowing in the rotor laminations (and so capable of being represented fairly accurately by a pure resistance shunting the rotor circuit) and partly by increase of rotor resistance due to skin effect in the conductors.

The first circuit for the deep-bar rotor is given in Table II; all the components have been chosen to give the best possible agreement with the test curve. Table III gives a simplified circuit in which R_1 is rather arbitrarily omitted. This circuit gives a better match over the motoring region of the torque curves.

No quantitative circuits for the multiple-cage motor were found, for reasons given in the following section.

TABLE II.—*Equivalent Circuit Components* (Ref. Fig. 1).

$R_1 = 1{\cdot}94\Omega$	$R_0 = 380\ \Omega$
$R_2 = 0{\cdot}955\Omega$	$X_0 = 67{\cdot}5\Omega$
$X = 4{\cdot}79\Omega$	$R_e = 15{\cdot}3\Omega$

TABLE III.—*Simplified Circuit*

$R_1 = 0$	R_0 } As above
$R_2 = 1{\cdot}13\Omega$	X_0 }
$X = 5{\cdot}65\Omega$	$R_e = 24\Omega$

DISCUSSION

The test readings (even when taken at a given speed with different supply voltages) show little scatter, and this confirms the accuracy of the corrections made. The general shape of all the curves is markedly asymmetrical; this can be seen by comparing Fig. 4 with Fig. 2 and Fig. 5 with the circular locus that simple theory predicts for a single-cage motor.

The circuit whose components are given in Table II is seen to give good agreement with the experimental torque curve only near synchronous speed (Fig. 4). The circuit given in Table III gives better agreement in the motoring and braking regions, but fails hopelessly in the generating region. There is serious disagreement between the theoretical and experimental current loci at high slip. Finally, the value of stator resistance which gives best agreement with the test curves is more than 100 per cent. in excess of that measured by voltmeter and ammeter on the machine. It is unlikely that adjustment of the circuit component values could lead to any great improvement in the correlation.

It might be thought that this disagreement was due only to variation in effective resistance with speed caused by the shape of the rotor conductors (Fig. 3a) and that the multiple-cage rotor (whose conductors are either circular or approximately square in cross-section) would give more consistent results. However, the asymmetry of the curves (for example, the absence of any maximum hyper-synchronous torque to balance the two well-marked sub-synchronous maxima) led the author to assume that if a circuit were to be calculated good numerical agreement could not be expected.

It will be instructive to compare the limitations noted above with the actual tests.

(1) Both torque curves show effects due to the presence of harmonic fields, especially at a speed of $-\frac{N_s}{5}$ (slip = 1·2).

(2) The deep-bar current locus (Fig. 5) shows that, at high slip, the actual lagging component of the current is unduly high. This suggests a reduction in circuit reactance as the high current causes saturation effects, and this is borne out by the current readings in Table I, which increase more than proportionally with voltage.

(3) A comparison of Figs. 2 and 4 shows the error that would be introduced if the rotor resistance were assumed to be constant and the rotor magnetic drag were neglected.

(4) An additional test at synchronous speed (in which current was plotted against voltage applied) showed a noticeable departure from linearity at the rated supply voltage of 230 volts.

CONCLUSION

The torque curves and current loci for the motors tested are given in Figs. 4 to 7. They are in many ways typical of those for small high-torque squirrel-cage motors, and differ markedly from those for a plain induction motor.

Alternative circuits for the deep-bar machine are given in Tables II and III, and curves recalculated from them are superimposed on the test curves. The agreement is not good, and this is mainly attributed to the complexity of the current dis-

tribution in the rotor bars, which is not amenable to representation by a linear circuit. It is not likely that greater success could be obtained for the multiple-cage rotor.

In conclusion, it may be said that, although the equivalent circuit is of value in the investigation and design of induction motors, it may have serious limitations when applied to small machines, and these limitations must be recognised and allowed for. In general, equivalent-circuit methods must be applied cautiously whenever it is suspected that the components of a system are working out of their linear range.

Acknowledgment.—The author wishes to thank Professor F. Brailsford for the use of the Pender Laboratories at University College, London, and Mr. C. E. Gimson and Mr. B. C. Brookes, of the University Academic Staff, for advice and help.

ANGLO-AMERICAN AERONAUTICAL CONFERENCE

Structures, Materials, Propulsion

Continued from page 379, September 20

In the first part of our review of the sixth Anglo-American Aeronautical Conference, we dealt mainly with the "down to earth" problem. In this final article we cover the possibilities of nuclear power for the long-range aeroplane, some of the material and structural problems encountered at high speeds, and the concept of "fail-safe" structures. The research aspect of ultra-high speed is considered elsewhere in this issue. The complete list of conference papers was published at the end of last week's article.

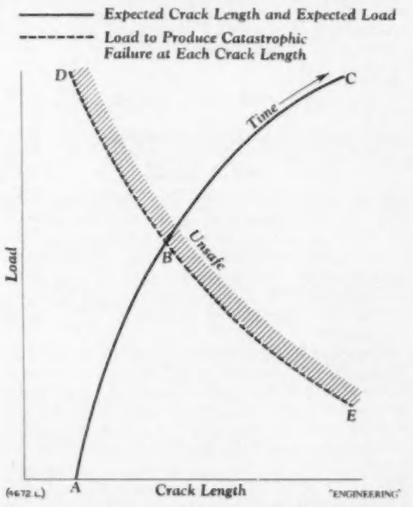


Fig. 6 Relations between probable load and expected crack length, and catastrophic load for failure at a given crack length.

FAIL-SAFE STRUCTURES

A structural topic which attracted a large attendance at the conference, applicable to all types of aircraft but probably of primary interest to commercial aeroplane operators and constructors, was the "fail-safe" philosophy, based on the premise that unforeseen damage may occur during flight and may remain undetected, and that the aeroplane should still retain sufficient strength to fly safely until the next inspection period. This concept demands ideally a statistical approach combined with experience—an assessment of the probable loads likely to be encountered during the period between inspections, and the relating of the expected maximum load to the longest crack likely to be unobserved by the inspectors, and the load required to produce catastrophic failure at each crack length. In Fig. 6, point B, where the two curves intersect determines the maximum allowable crack length—from which would be deduced the maximum allowable inspection period—and the "fail-safe" design load. In practice, no such rational approach is at present possible due to lack of data and experience, and arbitrary design loads have to be assumed.

The detail design of the structural members to comply with the fail-safe concept demands alternative paths for the loads to follow—for instance, distributed spar booms rather than heavily concentrated members, and duplicated spar webs. It also demands the provision of crack arrestors or, in wings, the splitting of the surface by spanwise joints, so that prescribed crack limits are provided. Tests on integrally stiffened panels, and riveted and bonded skin-and-stringer constructions by the Bristol Aeroplane Company, Limited, have suggested that bonded construction appears to offer the lowest rate of crack spread. In fuselage structures, frames directly attached to the skin are most desirable crack arrestors (Figs. 7 and 8), and the customary notched cut-out to accommodate the continuous longitudinal stringer is a source of weakness. One method of overcoming the weakness is to use circumferential steps between the skin and the frame.

Pressure-cabin windows are preferably of two-panel construction, one panel being unloaded but ready to take up the load if the other fails (Fig. 9). In windscreens, there is an added advantage in having a vinyl interlayer between two sheets of toughened glass. Even if both glass sheets fail, the vinyl is still capable of carrying the pressure load.

The fail-safe concept depends on effective inspection, and it is important that the aircraft designer should tell the inspector where to look and what to look for. It follows that the structure should be designed for easy access and inspection.

HOW TO WITHSTAND THE HEAT?

As supersonic speeds go up, the thermal thicket becomes even denser, and materials problems arise. Table I, on page 408, demonstrates that, in particular, material for electrical insulation, tank sealants, tyres, adhesives and pressure seals require much development, but some qualification of the more promising looking materials is necessary. The high-temperature properties of ceramics, silica and silica-glass for radio transparencies are available only at the expense of extra weight, but efforts are now in progress to produce foam-filled ceramic sandwiches for radomes. Ceramics are brittle and have poor thermal shock resistance, and are at present unlikely candidates for airframe main structures—although there are reports of interesting investigations in the United States on the structural use of prestressed reinforced ceramics, analogous to reinforced concrete, using pretensioned stainless-steel reinforcing wires. The more immediate possibilities of ceramics and cermets lie in their use as insulating coatings sprayed

Fig. 7 Failure of unstiffened pressure cylinder after a crack-propagation test.

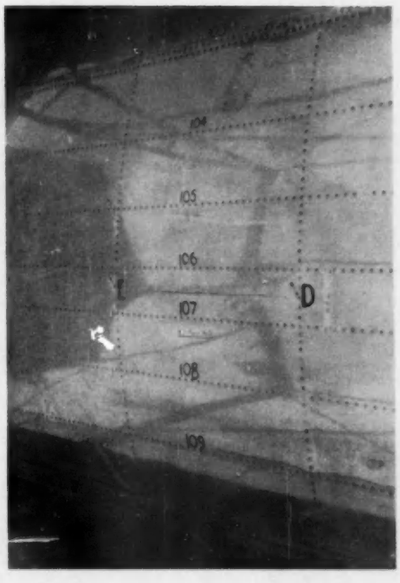


Fig. 8 In a stiffened cylinder under test, a crack 14·5 in. long was arrested by the circumferential frames.

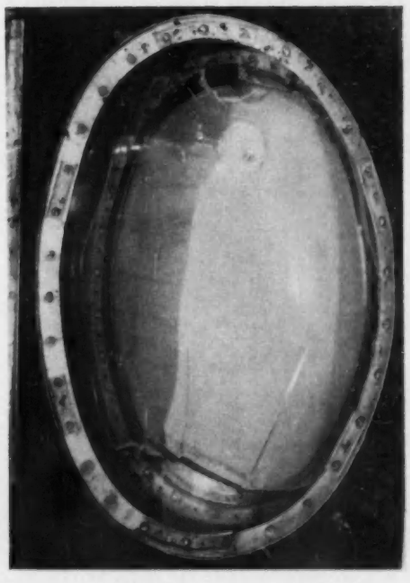
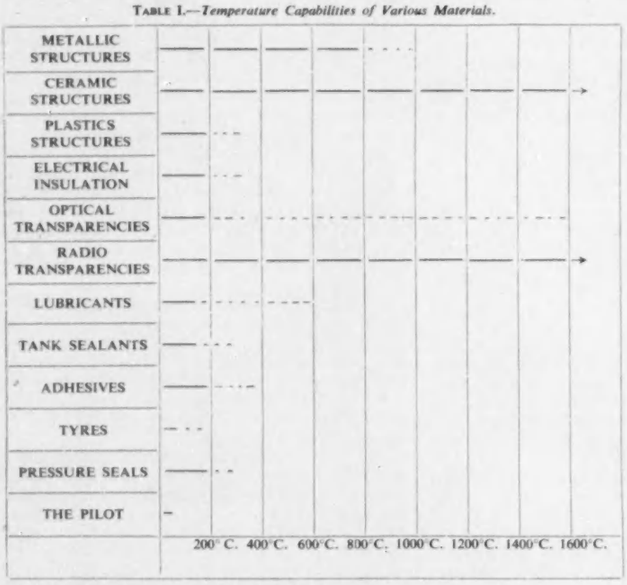


Fig. 9 The sudden failure of an inner panel of a double window leaves the outer (rear) panel undamaged.

Continuing **Design**

TABLE I.—*Temperature Capabilities of Various Materials.*



on to metal—but this technique also requires much development.

Aerodynamic heating complicates structural design by the introduction of differential temperature stresses between the shell and the internal structures. There are three ways in which such temperature stresses can be reduced: by reducing the effective depth of the internal structure, by insulation and by cooling. For speeds greater than about Mach 5, where the equilibrium temperatures are about 820 deg. C., the use of steel will become impracticable unless steps are taken to reduce the temperature. Insulation, by itself, however, will not alleviate kinetic heating stress, whereas cooling always has a beneficial effect both on the equilibrium temperature and on thermal stress. Once cooling has been introduced, further reductions in the equilibrium temperature of the structure can be achieved by putting insulation on the outside. Moreover, it has the effect of reducing the amount of cooling required to maintain the inside surface of the shell at a given temperature. For an aircraft flying at Mach 5, the amount of cooling required to bring the equilibrium temperature down to 320 deg. C, without insulation is about 1 kW per sq. ft. at 100,000 ft. At 50,000 ft., with the same cooling rate, insulation about $\frac{1}{4}$ to $\frac{1}{2}$ in. thick, with an insulation resistance of 450 deg. C. per kW per sq. ft., would be necessary.

NUCLEAR PROPULSION

There seems to be little immediate prospect of applying nuclear power to aircraft propulsion; but when it does reach the project stage it may lead to the rebirth of the flying boat, so that all operations can take place over water, to guard against fission-bomb effects over populated areas in the event of a crash.

It seems that no nuclear power plant has yet been conceived that is small enough and light enough for aircraft use. Moreover, unless very conservatively designed, present-day reactors occasionally go temperamental and shut down completely without warning—a characteristic that could not be tolerated in the air. For a passenger transport, a complete shield of water and steel some 3 ft. thick would be required, weighing several hundred tons—which puts the nuclear-powered air-liner well beyond the present bounds of possibility. However, the problem is considerably eased in the case of the military aircraft, and possibly the cargo aircraft, in which the shielding could be split, part being placed around the crew; it might also be possible to adopt the principle of "shadow" shielding, since the radiation from a reactor tends to travel in straight lines when in air. During take-off and landing, to avoid ground scatter from the reactor to the crew, it might be necessary to use conventionally fuelled engines. By these means the weight of the shielding system might be brought down to less than 100 tons; and, on this basis, a nuclear-powered military aircraft could probably be built—but it will take at least 15 years to solve all the problems.

The shielding problem has to be tackled by the experimental approach, and in the United States—who have given the atomic-powered aircraft considerably more thought than has the United Kingdom—a small reactor has been installed in an aircraft for this purpose. Furthermore, a reactor has been suspended in the air from four towers roughly 300 ft. high and measurements have been made on mock-up arrangements of aircraft shield design, and an air and ground-scatter of radiation. (Figs, 10 and 11.) It is perhaps significant that the United States are retrenching quite considerably on airframe investigations and are at present primarily concentrating on the propulsion system.

For the small aircraft reactor it seems fairly certain that the fuel would be highly enriched with uranium 235, and it would probably have a life approaching 100 days at full power before reprocessing was necessary. The cost would be about £1 million upwards, depending on size and design. For safety, it seems likely that the fuel might be some form of ceramic material, which reduces the chance of releasing large amounts of fission products in the event of a crash—provided that the fuel elements are scattered from the reactor. A gaseous coolant for conveying heat from the reactor to the engine seems to be indicated since this reduces the cooling requirement.

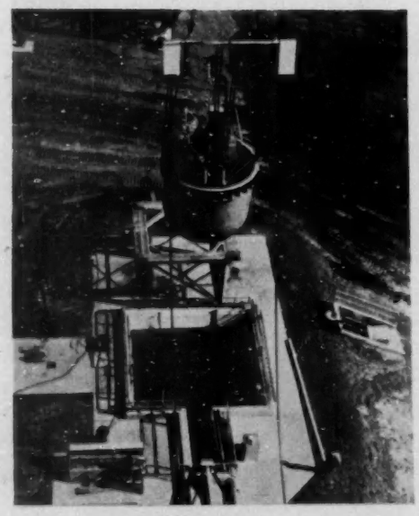


Fig. 10 The reactor and storage pool of the U.S. Atomic Energy Commission tower facility for studying shielding problems.

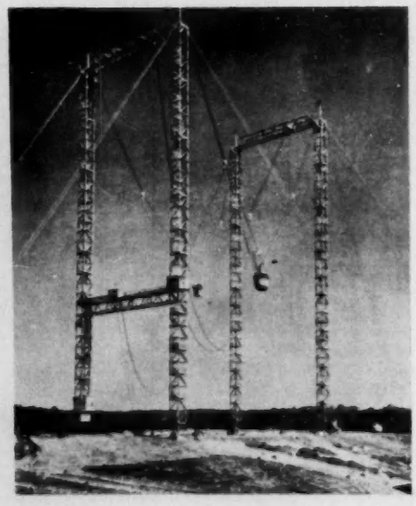


Fig. 11 A reactor airborne on the tower facility, which enables air and ground scatter of radiation to be determined.

★ ★ ★

CONDUCTING POSTAGE STAMPS

Before stamps on letters can be cancelled by machine the letters have to be rearranged with all the stamps in the top right-hand corner. This is a time-consuming process and its mechanisation has long been the goal of post office technicians. The latest solution to the problem is the introduction of electrically conductive stamps.

The experimental stamps will have one or two lines of conducting material running from top to bottom under the gum. Harrison and Sons, Limited, London, W.C.2, are printing the stamps. The conducting material to be employed is Naphthadag—an ink-like fluid made up of graphite (with the proprietary name Defloculated Acheson's graphite) in a solution of naphtha. The lines will be $\frac{1}{32}$ in. wide.

The lines, although black, will be virtually invisible from the front of the stamp, unless held up to the light. Only the most ardent stamp licker will be able to get at them, and they are quite harmless.

To scan the envelope, a machine is used that passes a high-voltage discharge through the envelope. The machine arranges the letters in piles according to the corner in which the stamp appears. When the discharge passes through the conducting line a recognition signal is given that initiates the transfer of the envelope into the appropriate pile. At the same time, the scanners will differentiate between ordinary letters and those paid at the 2*d.* printed paper rate, and will separate the two so that they can be dealt with independently. A stamp cancelling unit will be included in the machine.

The machine is to be given its first trial under operational conditions in the Southampton post office within the next two or three months. Treated stamps will be on sale a few weeks before the machine is ready, so that the stamps have time to come into general use before the experiment starts. Although this is not the first time that an experimental facing machine has been produced, it is believed that this is the first time that stamps in any country have been marked in this particular way to assist in postal mechanisation.

The treated stamps are being introduced purely for the purpose of the first operational trial of the letter facing machine. The future of the process will depend largely on the outcome of the trial and also on whether future research, which will continue independently, produces an alternative method of recognition that does not involve any visible marking of stamps.

HOW GOOD ARE SOVIET ENGINEERS?

Soviet engineers are known to be trained in great numbers; but what about their quality? To seek an answer to this question, Mr. E. P. Ward, a Deputy Editor of ENGINEERING, *has recently visited the Soviet Union, where he collected material for a series of articles. Two articles have already been published: the first introduced the Soviet engineer and his background; the second considered his sources of technical information. The third is concerned with the quality of Soviet engineering design.*

3—THE SOVIET ENGINEER AS A DESIGNER

No matter what facilities an engineer may have for practising his art, the ultimate test of his skill is the quality of his products, and the ease and economy with which they are produced. In attempting to assess the Soviet engineer as a designer, I have considered the following requirements. Does the design meet the needs of the user and fit the conditions for which it is intended? How much attention is paid to finish and refinement? To what degree are the problems of production borne in mind by the designer? What part do imagination and innovation play in Soviet designs? What are the standards by which designs are judged?

Designing for the User

In any problem of design the needs of the user must be considered first. But the user's needs can never be exactly ascertained: if a factory manager has never heard of spark erosion, how can he appreciate its value? Demand is the complex product of technical and economic intercourse—even in a Communist country.

In Britain and the West several complementary channels exist by which the customer can communicate his requirements to the designer—sales contacts, market and consumer research, advertising, consultation and the mechanism of the economic system generally. In a planned economy certain of these are excluded and the remainder are assumed by planning agencies, purchasing delegations, or research establishments. It appears to follow that consumer pressure in the Soviet Union can only make itself adequately felt at capital-equipment levels.

Mobile "embassies," or buying commissions, operate between industries, but generally at industrial rather than factory level. This system does not seem to be supplemented by the distribution of brochures or prospectuses. Thus one factory manager, whom I asked for descriptive literature, told me that "we have no need of advertising leaflets in a planned economy." Leaflets are occasionally printed but generally for export or exhibition purposes, rather than to lubricate internal commerce; though the monographs and up-to-the-minute texts prepared by research institutes may serve a similar purpose.

Such an approach is clearly inapplicable to the broader, diffuser market of the ultimate consumer. His basic needs—food, clothing, accommodation—can be recognised without much study, but the goods which add to his comfort or pleasure are less easily determined. Food supplies can be estimated on the basis of necessary calories and vitamins, but the ideal shape for a television set or a motor car can only be measured by a popularity rating. More difficult to judge is the relative demand, say, for refrigerators and washing machines. There is in addition the intangible demand for articles not yet in existence, a demand which must nevertheless be gauged if progress is to be made.

How does the Soviet Union approach these problems? Consumer demand has only recently been tackled seriously, and it is apparent that apart from traditional items Western consumer tastes are often used as a standard. Otherwise procedures are comparatively simple. If a store sells all its television sets within a few hours of delivery, then it is clear that more should be ordered, and consequently produced. At this stage, consumer demand expresses itself in terms of quantity rather than design, though products which are longer established or relatively easy to produce in numbers may be of high quality. Thus although the image on a modern Russian television screen retains the bluish tint of earlier British sets, dolls and other traditional items are often of fine craftsmanship.

It is significant that in 1955 the Soviet Union with a population of 200 million had only 6 million radio receivers and 80,000 television sets; whereas Britain with one-quarter the population issued 9½ million sound licences and 4½ million television licences. It should be borne in mind, however, that the total number of radio reception points in the Soviet Union, including rediffusion, was 26½ million, while on the other hand a household in Britain with one radio licence might have several sets. In Russia there are radio loudspeakers in many public places.

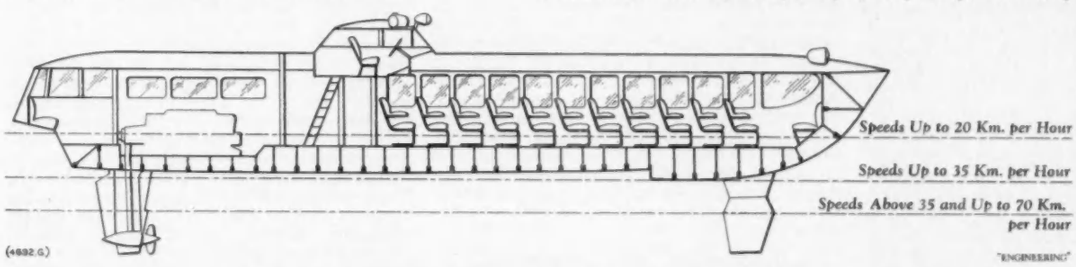
Unfortunately, the trial and error method of market study is not readily adapted to the development of new consumer products, and it seems that for this purpose a touchstone external to the Soviet Union is employed. Even the quality of Soviet-made machine tools is measured against Western machines, the characteristics of which are tabulated in detail. The methods by which standards are maintained will, however, be treated in another section of this article. In general, I concluded that the customer became more articulate in his demand as his responsibility rose, from the level of individual consumer to that of an executive in major capital industry. The aptness of design might be expected to follow the same pattern.

A second question is concerned with the degree to which products fit the conditions for which they are intended. Soviet engineers appear to pay considerable attention to the design of special-purpose equipment—a logical consequence of living in a large country, where even a narrowly specialist machine may be required in sufficient numbers to make manufacture economical. The Russians are quick to recognise their own peculiar conditions and build accordingly. Thus, since distances are great, most cars have seats which fold to form emergency beds. An immense range of tractors are produced, from high stilted narrow-track models (DT 40), for cotton fields, to the C-100B, with tracks one metre wide, designed to operate in peat bogs (pressure on ground 0·24 kg. per sq. cm.).

I was interested to note that 60 per cent. of the 500 or 600 machine tools made each year at the Sverdlov factory in Leningrad were designed for special purposes. This of course is no indication of overall Soviet practice, but I was told at Enims, the machine-tool research institute, that 789 types of "mass-produced" machine tools were made in 1955, while the projected figure for 1960 is 1,200. For a planned economy, in which duplication is avoided, these figures seem considerable, especially since they do not include the special machines produced, for example, at the ZIL commercial vehicle factory for its own purposes; ZIL has a single shop employing two shifts of 800 men devoted to tool production.

Much attention is paid to the use of local materials. Peat is abundant in Russia and black ridges where digging is in progress are a common feature of the countryside round Moscow. Considerable efforts have been made to use peat to best advantage both as fertiliser and as fuel, and the Shatura power station near Moscow is designed as a peat-burning plant. In Leningrad, experiments are in progress on peat-fired

Adventure in Soviet design. The "Rocket" hydroplane made at the Gorky docks is an unconventional river boat capable of carrying 66 passengers at nearly 40 m.p.h.



As its speed increases the "Rocket" is lifted hydrodynamically until its hull is clear of the surface. The air cushion under the hull serves to minimise pitching, rolling and other disturbances.

Continuing **Design**

TABLE I.—*Temperature Capabilities of Various Materials.*

	200° C.	400° C.	600° C.	800° C.	1000° C.	1200° C.	1400° C.	1600° C.
METALLIC STRUCTURES	——	——	——	——	- - -			
CERAMIC STRUCTURES	——	——	——	——	——	——	——	—— →
PLASTICS STRUCTURES	——	- - -						
ELECTRICAL INSULATION	——	- - -						
OPTICAL TRANSPARENCIES	——	- - -	- - -	- - -	- - -	- - -	- - -	- - -
RADIO TRANSPARENCIES	——	——	——	——	——	——	——	—— →
LUBRICANTS	——	- - -	- - -	- - -				
TANK SEALANTS	——	- - -						
ADHESIVES	——	- - -	-					
TYRES	— - -							
PRESSURE SEALS	——	- -						
THE PILOT	—							

on to metal—but this technique also requires much development.

Aerodynamic heating complicates structural design by the introduction of differential temperature stresses between the shell and the internal structures. There are three ways in which such temperature stresses can be reduced: by reducing the effective depth of the internal structure, by insulation and by cooling. For speeds greater than about Mach 5, where the equilibrium temperatures are about 820 deg. C., the use of steel will become impracticable unless steps are taken to reduce the temperature. Insulation, by itself, however, will not alleviate kinetic heating stress, whereas cooling always has a beneficial effect both on the equilibrium temperature and on thermal stress. Once cooling has been introduced, further reductions in the equilibrium temperature of the structure can be achieved by putting insulation on the outside. Moreover, it has the effect of reducing the amount of cooling required to maintain the inside surface of the shell at a given temperature. For an aircraft flying at Mach 5, the amount of cooling required to bring the equilibrium temperature down to 320 deg. C. without insulation is about 1 kW per sq. ft. at 100,000 ft. At 50,000 ft., with the same cooling rate, insulation about $\frac{1}{4}$ to $\frac{1}{2}$ in. thick, with an insulation resistance of 450 deg. C. per kW per sq. ft., would be necessary.

NUCLEAR PROPULSION

There seems to be little immediate prospect of applying nuclear power to aircraft propulsion; but when it does reach the project stage it may lead to the rebirth of the flying boat, so that all operations can take place over water, to guard against fission-bomb effects over populated areas in the event of a crash.

It seems that no nuclear power plant has yet been conceived that is small enough and light enough for aircraft use. Moreover, unless very conservatively designed, present-day reactors occasionally go temperamental and shut down completely without warning—a characteristic that could not be tolerated in the air. For a passenger transport, a complete shield of water and steel some 3 ft. thick would be required, weighing several hundred tons—which puts the nuclear-powered air-liner well beyond the present bounds of possibility. However, the problem is considerably eased in the case of the military aircraft, and possibly the cargo aircraft, in which the shielding could be split, part being placed around the crew; it might also be possible to adopt the principle of "shadow" shielding, since the radiation from a reactor tends to travel in straight lines when in air. During take-off and landing, to avoid ground scatter from the reactor to the crew, it might be necessary to use conventionally fuelled engines. By these means the weight of the shielding system might be brought down to less than 100 tons; and, on this basis, a nuclear-powered military aircraft could probably be built—but it will take at least 15 years to solve all the problems.

The shielding problem has to be tackled by the experimental approach, and in the United States—who have given the atomic-powered aircraft considerably more thought than has the United Kingdom—a small reactor has been installed in an aircraft for this purpose. Furthermore, a reactor has been suspended in the air from four towers roughly 300 ft. high and measurements have been made on mock-up arrangements of aircraft shield design, and an air and ground-scatter of radiation. (Figs. 10 and 11.) It is perhaps significant that the United States are retrenching quite considerably on airframe investigations and are at present primarily concentrating on the propulsion system.

For the small aircraft reactor it seems fairly certain that the fuel would be highly enriched with uranium 235, and it would probably have a life approaching 100 days at full power before reprocessing was necessary. The cost would be about £1 million upwards, depending on size and design. For safety, it seems likely that the fuel might be some form of ceramic material, which reduces the chance of releasing large amounts of fission products in the event of a crash—provided that the fuel elements are scattered from the reactor. A gaseous coolant for conveying heat from the reactor to the engine seems to be indicated since this reduces the cooling requirement.

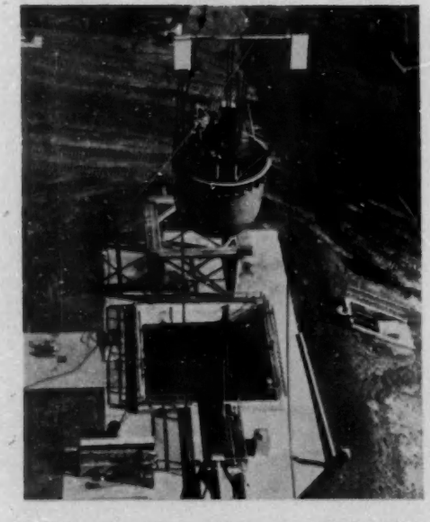


Fig. 10 The reactor and storage pool of the U.S. Atomic Energy Commission tower facility for studying shielding problems.

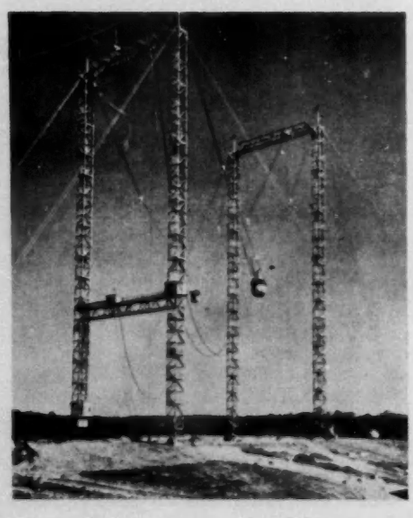


Fig. 11 A reactor airborne on the tower facility, which enables air and ground scatter of radiation to be determined.

★ ★ ★

CONDUCTING POSTAGE STAMPS

Before stamps on letters can be cancelled by machine the letters have to be rearranged with all the stamps in the top right-hand corner. This is a time-consuming process and its mechanisation has long been the goal of post office technicians. The latest solution to the problem is the introduction of electrically conductive stamps.

The experimental stamps will have one or two lines of conducting material running from top to bottom under the gum. Harrison and Sons, Limited, London, W.C.2, are printing the stamps. The conducting material to be employed is Naphthadag—an ink-like fluid made up of graphite (with the proprietary name Defloculated Acheson's graphite) in a solution of naphtha. The lines will be $\frac{1}{32}$ in. wide.

The lines, although black, will be virtually invisible from the front of the stamp, unless held up to the light. Only the most ardent stamp licker will be able to get at them, and they are quite harmless.

To scan the envelope, a machine is used that passes a high-voltage discharge through the envelope. The machine arranges the letters in piles according to the corner in which the stamp appears. When the discharge passes through the conducting line a recognition signal is given that initiates the transfer of the envelope into the appropriate pile. At the same time, the scanners will differentiate between ordinary letters and those paid at the 2*d.* printed paper rate, and will separate the two so that they can be dealt with independently. A stamp cancelling unit will be included in the machine.

The machine is to be given its first trial under operational conditions in the Southampton post office within the next two or three months. Treated stamps will be on sale a few weeks before the machine is ready, so that the stamps have time to come into general use before the experiment starts. Although this is not the first time that an experimental facing machine has been produced, it is believed that this is the first time that stamps in any country have been marked in this particular way to assist in postal mechanisation.

The treated stamps are being introduced purely for the purpose of the first operational trial of the letter facing machine. The future of the process will depend largely on the outcome of the trial and also on whether future research, which will continue independently, produces an alternative method of recognition that does not involve any visible marking of stamps.

HOW GOOD ARE SOVIET ENGINEERS?

Soviet engineers are known to be trained in great numbers; but what about their quality? To seek an answer to this question, Mr. E. P. Ward, a Deputy Editor of ENGINEERING, *has recently visited the Soviet Union, where he collected material for a series of articles. Two articles have already been published: the first introduced the Soviet engineer and his background; the second considered his sources of technical information. The third is concerned with the quality of Soviet engineering design.*

3—THE SOVIET ENGINEER AS A DESIGNER

No matter what facilities an engineer may have for practising his art, the ultimate test of his skill is the quality of his products, and the ease and economy with which they are produced. In attempting to assess the Soviet engineer as a designer, I have considered the following requirements. Does the design meet the needs of the user and fit the conditions for which it is intended? How much attention is paid to finish and refinement? To what degree are the problems of production borne in mind by the designer? What part do imagination and innovation play in Soviet designs? What are the standards by which designs are judged?

Designing for the User

In any problem of design the needs of the user must be considered first. But the user's needs can never be exactly ascertained: if a factory manager has never heard of spark erosion, how can he appreciate its value? Demand is the complex product of technical and economic intercourse—even in a Communist country.

In Britain and the West several complementary channels exist by which the customer can communicate his requirements to the designer—sales contacts, market and consumer research, advertising, consultation and the mechanism of the economic system generally. In a planned economy certain of these are excluded and the remainder are assumed by planning agencies, purchasing delegations, or research establishments. It appears to follow that consumer pressure in the Soviet Union can only make itself adequately felt at capital-equipment levels.

Mobile "embassies," or buying commissions, operate between industries, but generally at industrial rather than factory level. This system does not seem to be supplemented by the distribution of brochures or prospectuses. Thus one factory manager, whom I asked for descriptive literature, told me that "we have no need of advertising leaflets in a planned economy." Leaflets are occasionally printed but generally for export or exhibition purposes, rather than to lubricate internal commerce; though the monographs and up-to-the-minute texts prepared by research institutes may serve a similar purpose.

Such an approach is clearly inapplicable to the broader, diffuser market of the ultimate consumer. His basic needs—food, clothing, accommodation—can be recognised without much study, but the goods which add to his comfort or pleasure are less easily determined. Food supplies can be estimated on the basis of necessary calories and vitamins, but the ideal shape for a television set or a motor car can only be measured by a popularity rating. More difficult to judge is the relative demand, say, for refrigerators and washing machines. There is in addition the intangible demand for articles not yet in existence, a demand which must nevertheless be gauged if progress is to be made.

How does the Soviet Union approach these problems? Consumer demand has only recently been tackled seriously, and it is apparent that apart from traditional items Western consumer tastes are often used as a standard. Otherwise procedures are comparatively simple. If a store sells all its television sets within a few hours of delivery, then it is clear that more should be ordered, and consequently produced. At this stage, consumer demand expresses itself in terms of quantity rather than design, though products which are longer established or relatively easy to produce in numbers may be of high quality. Thus although the image on a modern Russian television screen retains the bluish tint of earlier British sets, dolls and other traditional items are often of fine craftsmanship.

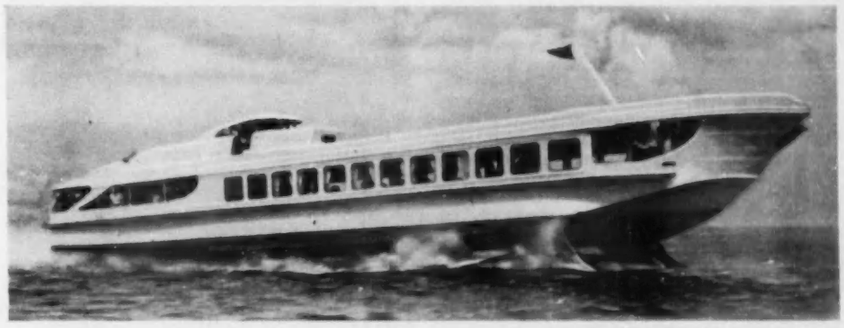
It is significant that in 1955 the Soviet Union with a population of 200 million had only 6 million radio receivers and 80,000 television sets; whereas Britain with one-quarter the population issued 9½ million sound licences and 4½ million television licences. It should be borne in mind, however, that the total number of radio reception points in the Soviet Union, including rediffusion, was 26½ million, while on the other hand a household in Britain with one radio licence might have several sets. In Russia there are radio loudspeakers in many public places.

Unfortunately, the trial and error method of market study is not readily adapted to the development of new consumer products, and it seems that for this purpose a touchstone external to the Soviet Union is employed. Even the quality of Soviet-made machine tools is measured against Western machines, the characteristics of which are tabulated in detail. The methods by which standards are maintained will, however, be treated in another section of this article. In general, I concluded that the customer became more articulate in his demand as his responsibility rose, from the level of individual consumer to that of an executive in major capital industry. The aptness of design might be expected to follow the same pattern.

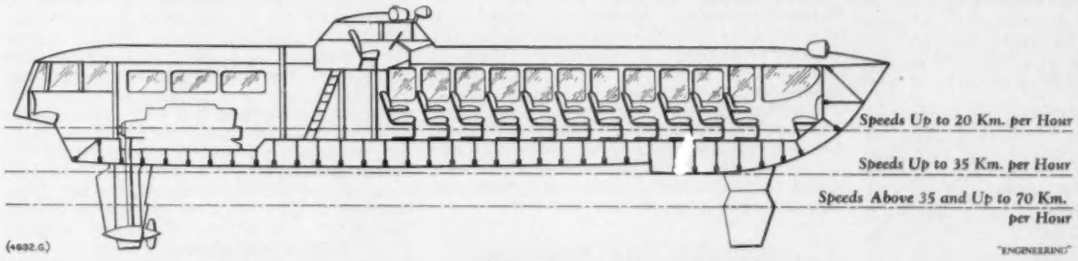
A second question is concerned with the degree to which products fit the conditions for which they are intended. Soviet engineers appear to pay considerable attention to the design of special-purpose equipment—a logical consequence of living in a large country, where even a narrowly specialist machine may be required in sufficient numbers to make manufacture economical. The Russians are quick to recognise their own peculiar conditions and build accordingly. Thus, since distances are great, most cars have seats which fold to form emergency beds. An immense range of tractors are produced, from high stilted narrow-track models (DT 40), for cotton fields, to the C-100B, with tracks one metre wide, designed to operate in peat bogs (pressure on ground 0·24 kg. per sq. cm.).

I was interested to note that 60 per cent. of the 500 or 600 machine tools made each year at the Sverdlov factory in Leningrad were designed for special purposes. This of course is no indication of overall Soviet practice, but I was told at Enims, the machine-tool research institute, that 789 types of "mass-produced" machine tools were made in 1955, while the projected figure for 1960 is 1,200. For a planned economy, in which duplication is avoided, these figures seem considerable, especially since they do not include the special machines produced, for example, at the ZIL commercial vehicle factory for its own purposes; ZIL has a single shop employing two shifts of 800 men devoted to tool production.

Much attention is paid to the use of local materials. Peat is abundant in Russia and black ridges where digging is in progress are a common feature of the countryside round Moscow. Considerable efforts have been made to use peat to best advantage both as fertiliser and as fuel, and the Shatura power station near Moscow is designed as a peat-burning plant. In Leningrad, experiments are in progress on peat-fired



Adventure in Soviet design. The "Rocket" hydroplane made at the Gorky docks is an unconventional river boat capable of carrying 66 passengers at nearly 40 m.p.h.



As its speed increases the "Rocket" is lifted hydrodynamically until its hull is clear of the surface. The air cushion under the hull serves to minimise pitching, rolling and other disturbances.

Continuing Design

gas-turbines, though as in this country the development of a satisfactory commercial model has yet to be attempted. Coal in certain areas is distributed in thin seams, and underground gasification has been practised for 15 years in such areas as Tula, Kuzbas and Donbas. A complete gas-turbine power station is being built at the LMZ turbine factory in Leningrad for use in conjunction with coal gasification. The plant, which is designed to operate with a gas temperature of 650 deg. C., will have an output of 12 MW. It will comprise one high-pressure and one low-pressure gas-turbine, three air compressors, three gas compressors, two combustion chambers, two regenerators for incoming air, and four for the gas. A similar station of 25 MW is to be completed in a few years. No large gas-turbines have been built.

Conversely, it is sometimes possible to judge what materials are available from the types of plant constructed. Thus the almost exclusive concentration on enriched fuels in the Soviet atomic power programme suggests that uranium diffusion plants have been operated on an enormous scale and that there are now considerable stocks of uranium 235, originally produced for military purposes. It also presupposes that by the time these stocks have been consumed the Soviet authorities expect to have either an alternative source of nuclear power, or a method of separating the uranium isotopes far more cheaply than by the conventional diffusion process.

Designers also take into consideration the extremes of cold found in parts of the Soviet Union and the poor road surfaces met in remote areas. Thus one motor truck (ZIL 157) is fitted with a device whereby the tyre pressure can be varied from the cab during motion in accordance with changes in road surface—a low pressure affording an improved grip where slippery or loose surfaces are encountered. The GAZ 56 incorporates a differential which in the event of wheelspin transmits 25 per cent. of the engine's power to the non-spinning wheel. The MAZ 530 is a 40 ton truck with an exhaust-gas heating system designed to prevent loads freezing solid in cold weather.

The MAZ 530 also illustrates the tendency for equipment in the Soviet Union to be large. It is designed for use in conjunction with large excavators or draglines, where bucket capacity may exceed the complete load of smaller trucks. A projected walking dragline has a 100 metre boom and a bucket capacity of 25 cub. metres, with an estimated rate of working of 1,500 cub. metres per hour. Operated by seven men, or a minimum of four, it weighs 2,600 tons, requires an external electricity supply at 6,000 volts, and is driven by engines consuming a total of 10,120 kW. It is being built at the Uralmash factory. Draglines with 14 and 20 cub. metre bucket capacities are already operating. A 70,000 ton hydraulic press is also reported to have been completed, while LMZ have built for the Kuibishev scheme 20 Kaplan turbines each of 126 MW capacity, said to be the largest in the world. This emphasis on size is not unexpected; a vast country with largely unexploited resources makes a large-scale approach practicable, even necessary; indeed, the first words of the Soviet national anthem: "Shirokaya strana" mean "Wide country." Thus with such great distances to cover it is not surprising that a 400 kV transmission line is already in operation between Kuibishev and Moscow. Factories too are large by United Kingdom standards; the First State Ball Bearing factory has 10,000 employees and I was told that there were ten like it; while ZIL has 40,000 employees.

The size philosophy indicates that designers recognise the special conditions which obtain in the Soviet Union, but it can of course be carried too far. Thus, though small cars exist, the Moskvich for example, probably a major proportion of those on the streets in Moscow are so big as to represent a considerable wastage of fuel without providing a particularly enhanced service. The Soviet Union is, of course, not the only country that favours large cars. It is significant for us, perhaps, that the size philosophy is likely to prove attractive to the underdeveloped continents.

It seems clear from these examples that the Soviet engineer takes considerable pains to accommodate his designs to the conditions in which they will be used, but that the mechanisms for creative and dynamic evolution are often pedestrian. Nevertheless, the official U.S.S.R. statistical abstract states that, in 1955, over a million inventors and "rationalisers" submitted over 2 million inventions, technical improvements and rationalisation proposals of which 1,160,000 were introduced into production.

The number of suggestions accepted in one year in British industry has been estimated at roughly 360,000, with over a million submitted. Patents accepted during the same period were approximately 21,000, with nearly twice the number submitted. It should be borne in mind that the industrial working population in Britain is only 8 million as against roughly 17 million in the Soviet Union, though the population of the U.S.S.R. is roughly four times Britain's. In comparing these figures it should be realised that, in Britain, improvements introduced by production or design staff might not be included in these totals.

Innovation and Invention

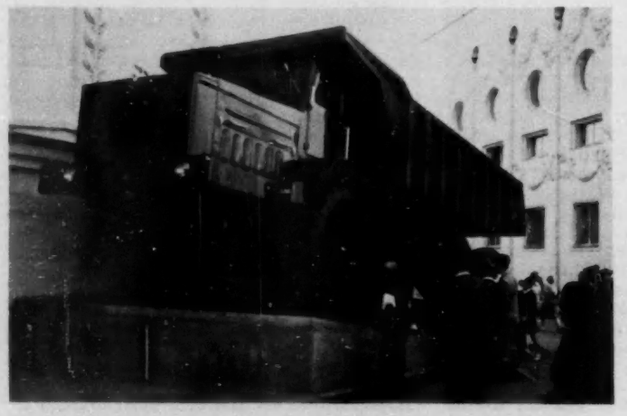
The fact that inventors and inventions are listed in an official book of statistics suggests that the Soviet authorities place a high value on innovation. There are, in fact, many indications of original technical thinking, even adventurousness, as may be gathered from the comparatively large hydroplane illustrated on page 409. But there are also widespread signs of imitation.

Many machine tools in current use, though carrying the monogram of a Soviet factory, are so close in design to particular Western machines, that there can be little doubt that the Western tool has been used as a model, even allowing that similar applications require similar equipment. The Russians are not alone in this approach; I saw a facsimile of a Parker pen, identical with my own but for a Chinese inscription. Certain cars display a similar resemblance—one type of Moskvich, for example, appears to follow an Opel design, even to the pattern on the radiator grille. When visiting the ZIL factory (formerly ZIS—S for Stalin), I had the temerity to suggest to its director that the large ZIS automobile was almost indistinguishable from a well-known Packard. He explained very patiently that contemporary models were often similar; it was a matter of fashion. Had he asked me to distinguish between a 1957 Packard and a Cadillac I should have been at a loss. Nevertheless, the existence of photocopies of Western journals suggests that the Soviet authorities have no scruples about imitation if it can serve a useful purpose.

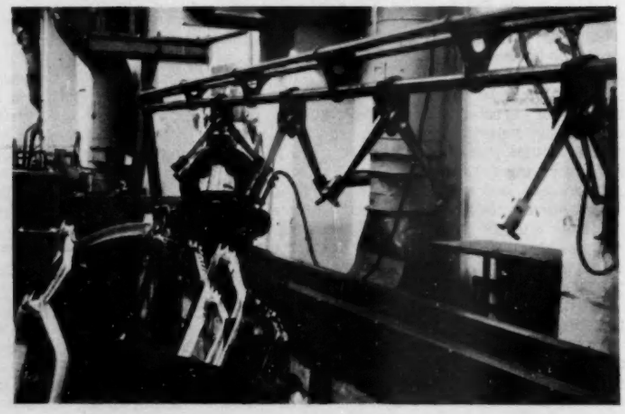
From the Soviet point of view such imitation is expedient. A country anxious to catch up its rivals cannot afford to waste time plodding through routine work; better to copy accepted designs and proceed from there. During my interview with Academician P. I. Kapitsa, I put this proposition to him. He agreed.

But it would be misleading to suppose that imitation precludes invention. Many recent Soviet machine tools are of quite independent design. New techniques are continually being developed. I saw demonstrated at Tsnitmash (the heavy-industry research institute), a process whereby steel components as much as one square metre in cross-section could be welded together. Academician E. O. Paton, who invented the "flux-bath" process, has recently described it in London. The Russians have devised a novel method of continuous casting, on an incline, using facing link tracks. Nothing is ever entirely new, but items which were fresh to me included the use of a magnetically susceptible powder in conjunction with an electromagnetic field to grip delicate items, such as piston rings, for machining; a vibrator applied to a vertical boring machine to give a smooth finishing cut; the combination of high-frequency and ultrasonic methods to give rapid penetration in surface hardening; and the use of vacuum bells to enclose ladles of molten steel.

Improvisation in factories is quite common. Apart from the production of special-purpose machine tools at ZIL, I saw a neat and simple device, designed and built at the Electrosila works, Leningrad, whereby generator windings could be automatically taped with insulation.



The MAZ 530 40 ton truck incorporates an exhaust-gas heating system to prevent the load from freezing solid. Many items of equipment are designed for use in special conditions—remote areas or climatic extremes.



Automatic machine for binding insulation on to generator windings. The series of double arms support the conductor and open in turn, allowing the rotary binding mechanism to pass along the carriage way.

Another machine had been devised for automatically fabricating mica insulation—I was told that to perform this task automatically was extremely difficult, and it was the first such machine to prove successful. As explained last week, comprehensive machinery exists to ensure that new ideas are quickly and widely incorporated in current designs.

The Russian is quite capable of solving problems in his own way. The visitor may be surprised to learn that Moscow's three-dimensional cinema was operating long before the West made any commercial experiments in this direction. He may also be shocked to see his driver pass a red traffic light without even a guilty look. Later he may learn that red in this context does in fact mean much the same to a Russian as an Englishman; however, at a Moscow crossroads if the light is red, the driver may bleed right (since he drives on the right). The visitor may notice that there are two green lights (placed at the top) in addition to the amber. If one green is showing the motorist may proceed straight ahead; if two, then he may turn left. Sometimes Russian solutions are complicated, but they have their advantages.

Finish and Refinement

Though not strictly a design consideration, finish is a quality that at least in Western eyes takes an important place. But it is reasonable to suppose that in a planned economy, where competitive sales do not apply, less attention is paid to superficial refinements. Experience confirms this. The Soviet engineer tends generally, at least in the domain of capital equipment, to be contented if a machine works well, irrespective of its appearance. Such an attitude has its advantages. The virtue of the T34 war-time tank and the more recent MIG fighter lay in their lack of refinements; in battle conditions refinements require too much servicing. Modern consumer products on the other hand are normally quite well finished—the clocks in all the cars I travelled in were running to time; a toy Petrushka with flexible arms and legs which I purchased was neat, well painted and strongly made; gramophone-record reproduction is of high fidelity.

Elsewhere, finish seems to be largely forgotten. Though all the drawing offices I visited were equipped with mechanical draughting appliances, the balance weights were usually crude castings. The steel cover plates shielding the Soviet Union's first power reactor appeared to be rough and ill-fitting. However, where care and accuracy was necessary—in the fuel elements, for example—the finish was of a high order. The enriched-uranium fuel elements are cooled by pressurised water contained in stainless-steel channels. Since stainless steel is a voracious neutron absorber, the quantity present must be carefully limited, and precise manufacture is essential.

Nevertheless, high finish, even where it is not essential to the working of the product, may often be desirable. The operator with a smart lathe will tend to keep it clean, just as a smart soldier is likely to be a confident and efficient fighting man.

Design for Production

Utility is not the only criterion of design, for a product that cannot be made serves little purpose. The ideal design is one that both satisfies the customer and involves a minimum of labour, skill, materials and special tools in its production. How well do Soviet designs meet this requirement?

Reference has already been made to the Soviet industrial consumer's disregard for finish; in general too he prefers a simple to a complex product—"less to go wrong." Both these requirements simplify the designer's task. In addition, a considerable degree of standardisation is acceptable; in Moscow certainly no more than 10 types of car, including earlier models of the same line, are normally seen, and apartment houses, which are under construction in great

Central information and research organisations exist to spot new techniques and see they are generally exploited. The model 473 electro-erosion tool for producing hard metal dies from soft metal patterns can take an 8 kg. workpiece.

numbers, are of closely similar pattern. A carefully co-ordinated standards system permits interlocking production; it operates through the industrial research institutes, such as Enims, which submits proposed standards to the All-Union Standards Committee. The systematic adoption of new production methods further assists the designer; thus spark or electro-erosion machines reduce the problems of die manufacture, and large hydraulic presses have been constructed from plate using the flux-bath welding technique. Printed circuits are employed for electronic equipment, while the use of tubular construction, not only for dragline booms, but also for tower cranes is already well established.

Enims keeps a close watch on production techniques, and formulates policy to secure the maximum economy. Thus I was told that the "main purpose of machine tools was to make articles not cuttings." With this object, a decrease in the number of universal lathes and an increase in grinding machines has been planned. In 1955, of the 98,000 production machine tools manufactured, 30 per cent. were universal lathes; by 1960 output is planned to increase to 200,000 tools, of which only 20 per cent. will be universal lathes. The aim is to increase casting production—and hence grinding—and reduce wasteful metal-cutting procedures. It is of interest that the production of lathes in the United Kingdom is just over one-quarter of total machine-tool production, though, excluding capstan and turret lathes, the proportion is not as much as 15 per cent. The United Kingdom production of grinding machines is probably about 10 per cent. Another technique designed to reduce metal wastage is a cylindrical trepanning tool. It consists of a hollow steel cylinder over a metre long with four double-edged cutters arranged symmetrically around the periphery at one end. The cutting edges project inside the cylinder and outside. The cylinder would be gripped in the chuck of a large drill or vertical borer, and a drilling cut made up to one metre deep. In this way part of the waste material (a central cylindrical bar) will be retained intact. Enims has, besides specialist design departments for different kinds of tool, a general design department concerned with such problems as strength, rigidity and vibration, and another for the study of materials.

With these advantages, the Soviet designer is equipped to prepare practical and economic designs. A comparison between Soviet and British productivity in particular industries might give some indication of his success. Unfortunately, satisfactory comparative figures are not available. The British machine-tool industry in 1956, employing nearly 46,000 men, produced 155,000 tons (deliveries) of equipment. The Soviet industry produced 250,000 tons (roughly 120,000 tools), with nearly four times as many men—the Soviet machine-tool industry is said to have a trade-union membership of 180,000. The only conclusion to be gathered is that Soviet productivity is lower than Britain's, but the comparison depends on the assumption that the types of tool produced are comparable. If due margin of error is allowed, the two productivities can be regarded as roughly similar. A weakness of this comparison is Soviet concentration on capital industry, leading to a greater proportion of heavy machines (3 per cent. of total Soviet production comprises large units made to order). Machine tools are also built by factories for their own purposes, as at ZIL—a practice far less common in Britain.

In a year ZIL, with 40,000 employees, produces some 124,000 buses and motor lorries. The entire British annual production of commercial vehicles amounts to between 300,000 and 350,000, little more than twice the Soviet figure for one factory. The total number of employees in the British motor industry is between 300,000 and 450,000, something like ten times that employed at ZIL, but including, of course, those engaged on motor-car production, accounting perhaps for two-thirds or three-quarters of the total. Thus it can be seen again that productivity is of the same order in Britain and the U.S.S.R. It should not, of course, be overlooked that ZIL makes many of its own special-purpose tools; but, as against this, it concentrates, apart from bus production, on only one kind of 4 ton truck.

These comparisons are, of course, very unsatisfactory, but with the other considerations mentioned lead to the general conslusion that Soviet designs are at least as easy to produce as Western equivalents.

Criteria of Design

As stated in a previous article one of the functions of the industrial research institutes is to maintain and improve standards of design. The catalogue of Western machine tools I saw at Enims, for example, represented a standard by which Soviet tools could be judged—"to ensure that tools were not worse than foreign samples." I asked how the Soviet Union would manage if there were no Western world to set the pace. There were, I was told, three categories—standard, above standard and below standard. Designs below par were eliminated, and efforts were constantly made to raise the level. This was a substitute for competition. Where a factory fell particularly below standard on design or production, an inquiry would be held and the management might be replaced.

Apart from the problem of knowing exactly where to place the standard, this approach seems to lead to certain difficulties. For linear development it might be admirable, as in designing machine tools of greater accuracy or higher cutting speeds. The solving of existing problems could be tackled in the same way. But to initiate completely new developments, such a mechanism must surely be inadequate. Thus, given radio, television is merely a matter of solving a number of technical problems; but to envisage—and exploit—radio itself required an entirely different approach. Similarly, if the idea of a jet engine has already been formulated, then with a sufficient concentration of men and money a practical working unit can be developed.

The Russian is as inventive as the next man, but is his system sufficiently flexible to accommodate invention? Invention—of a creative rather than a problem-solving kind—is a disturbing influence requiring a constant readjustment of any industrial programme. Where ideas serve an existing purpose, they are no doubt welcomed and put to use, but are they equally acceptable when they mean revision of an adopted five-year plan? The Soviet designer fits his work well to the needs of user and producer, but can he change course in mid-stream?

Atomic Review

A Second Draught

LAST week we showed how a figurative quart could be drawn from a pint pot. The 500 MW nuclear power station to be built at Hinkley Point, Somerset, though little larger than its predecessors at Berkeley and Bradwell, is designed to produce some 70 per cent. more power. The improvement will be achieved with the aid of technical developments that have arisen during the 12 months since the first tenders were submitted. The effect of these changes was considered in a paragraph headed Addendum last week. The contract for the station, a model of which is illustrated in Fig. 1, has been awarded by the Central Electricity Authority to the English Electric—Babcock and Wilcox—Taylor Woodrow group. Some additional features of its construction are discussed below.

Shielding

Each reactor pressure vessel at the Hinkley Point station is to be contained wholly within a reinforced-concrete or biological shield, and a thermal shield of reinforced concrete and steel plates. As can be seen from Fig. 2, the two shields are separated by cooling air passages of varying width so that the thermal shield, with the associated cooling system, protects the biological shield from excessive temperatures and temperature gradients which would otherwise arise from nuclear and thermal radiation. The continuous flow of cooling air is discharged to atmosphere through filters designed to stop the passage of any irradiated particles. The fans can be operated continuously and there is also a standby fan to take over their duty during routine maintenance. The biological shield wall is surmounted by a concrete pile cap which is perforated to allow the passage of the fuel charge and reactor control tubes vertically into the reactor vessel. Secondary biological shields attenuate radiation which may escape through the openings for the gas circulating ducts between the reactor and plant and equipment outside the main biological shield. The shielding, which is to be built by Taylor Woodrow Construction Limited, will comprise 7 ft. thick reinforced concrete walls of duodecagonal shape, 90 ft. high from the reactor foundations, and with internal diameters of more than 75 ft. The pile cap will be a concrete slab 11 ft. thick. Concrete of extra high density is required and placing must be carried out to a particularly high standard of accuracy.

Gas Circulators

Gas is circulated through the reactor and steam-raising unit circuits by axial-flow circulators. The single-stage rotor blading is mounted on an overhung disc so that only one shaft seal is needed. The circular casing, which is of fabricated pressure vessel type, requires only one seal-welded flange seal against pressure in the circulator assembly. Whatever changes in heat output may occur, the temperature of the plant will be maintained approximately constant by varying the gas flow through the reactor in proportion to the heat output. This variation is obtained by controlling the speed of the circulator.

Gas Ducting

The main gas ducting is all of large diameter. Each heat exchanger or steam-raising unit is connected to the reactor pressure vessel by one duct entering the unit at the top. A similar duct at the bottom of each unit is joined to its associated inlet manifold. A blower re-circulation duct is connected to an intermediate section of the blower discharge and this duct is led to the associated steam-raising unit and connected to it between the banks of the lower-pressure boiler and low-temperature economiser. The main duct connecting each blower back to the reactor is taken from the blower discharge. Provision is made for circuits to check radiation release. Air-operated main gas-isolating valves are placed in each outlet duct between the reactor and steam-raising units and in the inlet ducts between each blower and reactor. Similarly, isolating valves are fitted in each blower re-circulation duct.

Safety valves are incorporated at appropriate points in the circuits and facilities for blow-down are provided, as well as exhaust equipment for evacuation of major volumes of gas. Constant-load supports are provided throughout for the ducting, valves, and other items.

Charge and Discharge

The principal components of the charge and discharge equipment are a "hole preparation" machine and a fuelling machine for storing new and irradiated fuel, preparing the reactor for fuelling, inserting new fuel, changing the position of the elements, withdrawing irradiated fuel from the reactor, and transferring it from machine to storage pond. Both machines are handled by an overhead crane above the reactor. Fuel is moved into and out of the reactor through charge tubes that lead out of the pressure vessel. The tubes are pressure sealed by plugs and cover plates. Each charge tube serves several channels and a charge chute bridges the gap between the end of the charge tube and the particular channel that is being refuelled. The fuelling machine carries the elements in its magazine and has an electrically-operated winding gear and pneumatic grab head to engage the fuel elements.

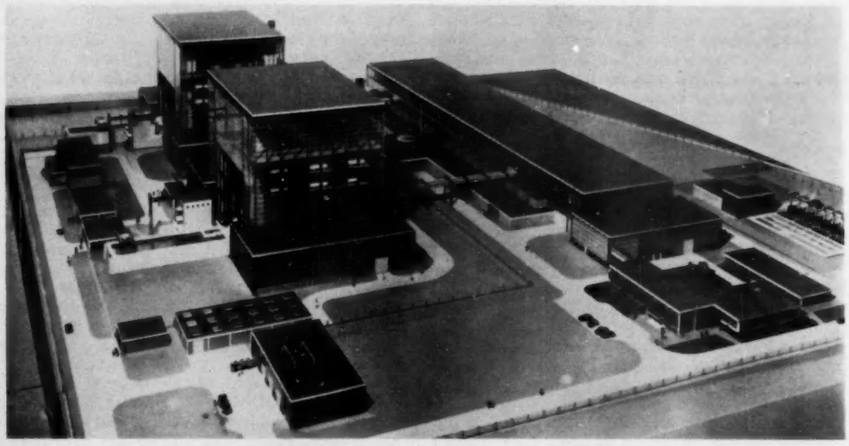


Fig. 1 Model of the 500 MW Hinkley Point nuclear power station to be built by the English Electric—Babcock and Wilcox—Taylor Woodrow group. Minor improvements in design developed in the last 12 months permit a 70 per cent. rise in output with little increase in size.

Spent-Fuel-Element Handling

The unloading equipment consists of a one-element manipulator, synchronised to operate with the fuelling machine, which transfers the elements from the pile-cap and discharges them into a water-filled skip. The loaded skips are then lowered in a hoist, totally enclosed within a biological shield, to the cooling pond below. A chute is also provided as an alternative means of transport for fuel elements to the pond in an emergency, and for the handling of damaged elements.

The cooling pond is divided into two areas by a watertight gate, the larger area being used for the main storage of spent fuel-elements, and the smaller section for damaged elements. The capacity of the former is sufficient to enable storage to be found for a suitable decay period of three to five months, under conditions that provide complete protection of personnel from the effects of radiation.

On completion of the storage period, the skips are taken by hoists to biologically-shielded loading bays where they are placed in heavy dry containers, or "coffins," mounted on power-operated transporter carriages to be taken to a wash-down area for final checking against radio-activity. From there they go to the railway vehicles for despatch to the processing plant of the United Kingdom Atomic Energy Authority. Periscopes are provided for observing the transfer of the elements from the manipulator to the skips, and also in the loading bays. All operations are remotely controlled from a central control room.

Power Plant

Each of the six main 3,000 r.p.m. hydrogen-cooled turbo-alternators has a continuous maximum rating of 93·5 MW at a generated voltage of 13·8 kV and 0·85 power factor. Three 33 MW variable-speed turbo-alternators, of which one acts as a standby, supply power for the gas blowers and are of sufficient capacity to allow for possible increased output from the reactors. Each main turbo-alternator is complete as a unit with its own auxiliaries, but the whole station has common steam and feed systems.

The main turbines are of the horizontal impulse reaction design with a high-pressure and two low-pressure cylinders, each double flow, solidly coupled in line. Two steam-dumping condensers, one normally a standby, are provided and each is capable of handling 10 per cent. of the total output from one reactor in the event of loss of load under emergency conditions.

Steelwork for Hinkley Point

United Steel Structural Company, Limited, a subsidiary of the United Steel Companies Limited, are to fabricate and erect the structural steelwork for Hinkley Point. Working with Taylor Woodrow Construction Limited, the civil engineering contractors for the project, United Steel Structural will supply between 8,000 and 9,000 tons of steelwork for the reactor building, turbine house, workshops and ancillary buildings. Erection is expected to begin towards the end of next year and the power station will be completed by the end of 1962.

General Notes

Starting Up Nuclear Reactors

The first commercial production in this country of neutron-source tubes (which will start up the two reactors at the Bradwell Nuclear Power station) is being undertaken by the Tube Investments subsidiary, Talbot Stead Tube Company, Limited, on behalf of the Nuclear Power Plant Company, Limited.

Neutron-source tubes consist of an antimony rod surrounded by a beryllium tube and enclosed in an outer sheath of stainless steel. The tubes are activated by insertion in a working reactor, as a result of which the emission of gamma rays from the antimony is initiated. These rays in turn cause neutrons to be released from the beryllium metal. This neutron source is used to initiate the chain reaction in a reactor under controlled conditions.

Calder Hall Type Reactor for United States

The United States Atomic Energy Commission has invited United States architect-engineering firms experienced in reactor work to submit proposals for the engineering design of a natural-uranium, gas-cooled, graphite-moderated nuclear power plant of 40 MW electrical capacity. September 23, 1957, has been set as the closing date for receiving proposals.

Development, design and engineering work on this prototype plant has been authorised by Congress. A report on the design, including cost estimates and schedule of construction, is to be submitted by the Commission to the Joint Committee on Atomic Energy of Congress not later than April 1, 1958. Construction of the prototype power plant has not been authorised by the Congress.

Water-Cooled Reactor for Carolina

Mr. Lewis L. Strauss, chairman of the U.S. Atomic Energy Commission, has announced that the Carolinas Virgina Nuclear Power Associates, Incorporated, of Charlotte, North Carolina, has submitted a formal proposal to the Commission for the development, design, construction, and operation of a nuclear power plant. The plant would be built under the A.E.C.-industry partnership programme. The proposal calls for a heavy-water cooled and moderated reactor fuelled with slightly enriched uranium. The plant would have net electrical capacity of about 17 MW. Carolinas Virginia Nuclear Power Associates comprise the South Carolina Electric and Gas Company, Columbia, South Carolina; the Carolina Power and Light Company, Raleigh, North Carolina; the Virginia Electric and Power Company, Richmond, Virginia; and the Duke Power Company, Charlotte, North Carolina. The proposal states that the group has engaged the Stone and Webster Engineering Corporation of Boston, Massachusetts, as architect-engineers for the proposed project and has made arrangements with Westinghouse Electric Corporation to develop and furnish plant equipment. The General Nuclear Engineering Corporation of Dunedin, Florida, has been engaged as consultant on nuclear science and engineering problems.

Arbor

Argonne National Laboratory recently announced the awarding of a contract to United Engineers and Constructors, Incorporated, of Philadelphia, for the detailed design of a boiling reactor facility to be erected at the Laboratory's Idaho Division site. Mr. J. H. McKinley, business manager of the Laboratory, said the anticipated cost of the facility, as now planned, would be about 8,500,000 dols. The installation will be known as the Argonne Boiling Reactor, or ARBOR, facility. Mr. McKinley said the facility will provide the basis for experiments designed to yield performance and operational data for various types of boiling-reactor concepts over a wide range of conditions useful for the development of this reactor type as a source of power.

Completion of the design work has been scheduled for May 1, 1958. The plant will be used to investigate full-scale boiling-water power reactor systems operating at pressures up to 2,000 lb. per sq. in. and developing 200 MW of heat under varying conditions.

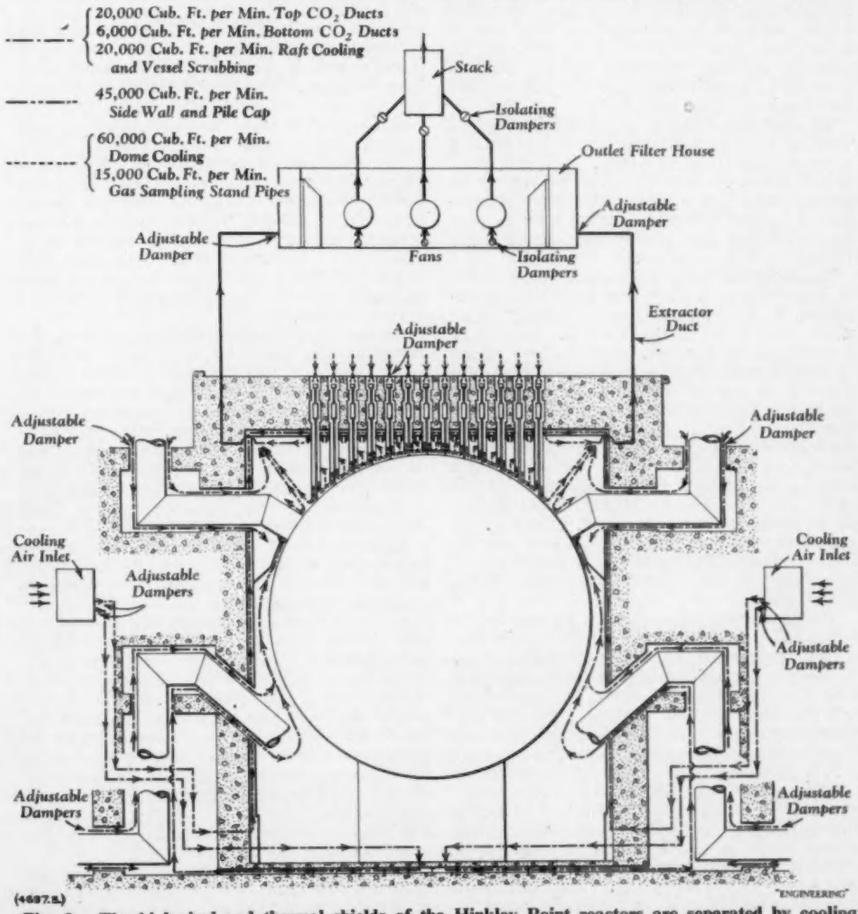

20,000 Cub. Ft. per Min. Top CO_2 Ducts
6,000 Cub. Ft. per Min. Bottom CO_2 Ducts
20,000 Cub. Ft. per Min. Raft Cooling and Vessel Scrubbing
45,000 Cub. Ft. per Min. Side Wall and Pile Cap
60,000 Cub. Ft. per Min. Dome Cooling
15,000 Cub. Ft. per Min. Gas Sampling Stand Pipes
Stack
Isolating Dampers
Outlet Filter House
Adjustable Damper
Fans
Extractor Duct
Cooling Air Inlet
Adjustable Dampers
(4697.2)
"ENGINEERING"

Fig. 2 The biological and thermal shields of the Hinkley Point reactors are separated by cooling passages through which there is a continuous flow of air.

6 GeV Electron Accelerator

Dr. R. S. Livingston, Professor of Physics at Massachusetts Institute of Technology, will be the honorary guest speaker at the Fourth National Symposium on Vacuum Technology. The Committee on Vacuum Techniques, Box 1282, Boston 9, Massachusetts, will sponsor the meeting, which will be held in Boston on October 9, 10 and 11, 1957. Dr. Livingston will describe the "Cambridge 6 Billion Volt Electron Accelerator," that is being built at Harvard University with funds provided by the Atomic Energy Commission. The facility will be used jointly by Harvard and Massachusetts Institute of Technology in research projects. The symposium is expected to attract 500 research, development and production engineers, who use high vacuums in their work. Authors from West Germany and Japan will be present, and the programme will contain some 25 papers.

Soil Moisture Content

That neutron-scattering may be used to determine soil moisture is reported in the paper "Field Experience with the Neutron-Scattering Method of Measuring Soil Moisture," published in *Soil Science* (vol. 83, page 151, 1957). The authors, Mr. G. L. Stewart and Mr. S. A. Taylor, point out that hydrogen nuclei influence the scattering of neutrons and since most of the hydrogen nuclei in soils occur in water, it should be possible to correlate the scattering of neutrons in the soil with moisture content. Because such measurements would be independent of the chemical or physical state of the water in the soil, many errors in present methods would be avoided.

In their paper the authors report on two years of field experience with neutron-scattering methods, describing instruments and techniques used and suggesting future applications. The moisture profiles for two selected soils—Wasatch fine sand, which has a low moisture content, and Millville loam, which has a somewhat higher one—are shown.

Uranium in Africa

The United Kingdom Atomic Energy Authority are ready to buy annually from existing or future mines in Kenya, Uganda, Tanganyika, Swaziland and British Guiana chemical concentrates containing up to 500 short tons of uranium oxide (U_3O_8). Contracts would cover a ten-year period from the coming into production of a mine, providing that the end date of the period does not extend beyond 1972. The Authority will offer prices which are reasonable in the light of world conditions at the time, having regard to the principles on which prices for uranium have been negotiated elsewhere. The Authority reserve the right at any time to bring other British Colonial and dependent territories within the scope of this notice. Any inquiry about this notice relating to East Africa should be addressed to the Officer in Charge, U.K.A.E.A. Office, Dodoma, Tanganyika. Any inquiry which relates to other Colonial and dependent territories should be addressed to the Principal Metals Officer, U.K.A.E.A., St. Giles Court, London, W.C.2.

Plutonium Re-cycling and Thorium

In his address as president of the recent UNESCO conference on the use of radioactive isotopes, Sir John Cockcroft surveyed present and potential applications of nuclear energy. In particular he referred to future development in the use of nuclear fuels. It was possible to foresee that by 1965-70 re-cycling of plutonium fuel would be well established and that plutonium might be re-cycled with thorium as a fertile material, leading to the thorium fuel cycle, which was likely to have better nuclear characteristics than the uranium fuel cycle for thermal reactors. Experience of radiation damage of plutonium enriched fuels, in some carriers had been very favourable. It could be predicted

that thorium resources would from 1970 onwards powerfully reinforce the energy available from uranium resources.

Companies Join Atomic Group

Fairey Aviation and Elliott Brothers (London) are to join the Atomic Power Construction group which already comprises Richardsons Westgarth, International Combustion, Crompton Parkinson, Holland Hannen and Cubitts, and Trollope and Colls. It is the most recently formed of the five nuclear power station construction groups. In some measure the decision is the result of a reduction in the amount of research and development work being undertaken on guided weapons and aircraft. Fairey are now in a position to allot technicians to nuclear power projects. Basic research facilities at Heston, which include electronic computers, will be made available. Elliott will provide computer facilities for the whole A.P.C. group at their Boreham Wood research laboratories, where they will undertake work on engineering and nuclear-physical calculations, automatic control systems and reactor performance analysis. Both companies are to devote some of their capacity to the development and production of small nuclear propulsion units, bearing in mind potential applications on land, sea and air. A.P.C. have appointed a team to oversea developments in each of these fields as well as those that have already become known as "conventional" fields of nuclear power station construction. Fairey have already had experience in the machining of fuel elements for Calder Hall. Other companies in the aircraft industry —Rolls-Royce and the Hawker group—have preceded them in the nucleonics field but they are large diversified engineering groups. The aircraft industry has research engineers to spare.

Enriched Fuel Makes All the Difference

The Soviet reactor programme outlined in Atomic Review on August 30 is marked by its concentration on reactors using enriched fuel. The experimental power station already operating has fuel enriched to as much as 5 per cent. Enriched fuel is also a characteristic of many American designs. The obvious conclusion is that the Soviet Union has, like America, one or more large diffusion plants for separating the fissile uranium isotope. Enriched uranium has presumably been stockpiled for nuclear weapons, and having written off its cost the Soviet authorities are anxious to find a use for it. No fuel could be cheaper—if it grew on trees or came in with the tide.

Some people have been misled by the unanimity of the Soviet and American programmes into doubting the wisdom of Britain's reactor policy, a key feature of which is the use of natural uranium. But Britain has negligible stocks of enriched uranium, and therefore must adopt an entirely different outlook—an outlook that, apart from the United States and U.S.S.R., the whole world shares. Given the extremely high cost of the diffusion process, Britain must confine her reactor programme to natural uranium reactors, until it is possible to use plutonium as enrichment. It is significant that the capital cost of natural-uranium reactors is considerably higher than those burning enriched fuel—a factor of special importance in view of the rise in Bank rate.

There is a further possibility. It is rumoured that the centrifugal separation process, described in Atomic Review on July 20, 1956, will soon be operating in Germany on a pilot-plant scale. It is also said that the process consumes one-eighth of the power used by a corresponding diffusion plant. The consequences of such a development could be far-reaching.

Construction

PLANS FOR FUTURE BRITISH POWER STATIONS

For several years the construction programme of the Central Electricity Authority has been curtailed by Government action, but even under those limitations, the increase in generating capacity over the past few years has been enormous (it has more than doubled since 1948), and even greater increases have been planned for the future. The increase during the six years from 1957 to 1962 is planned at 44 per cent., according to the C.E.A.'s Report for the year ended March 31, 1957.* This represents a net addition of some 9,000 MW output capacity, including 1,275 MW of nuclear plant. The present installed capacity is approximately 22,572 MW, a record total of 1,828 MW (output capacity) having been commissioned in 1956-57.

The yearly totals of new plant authorised by the Government (as quoted in the Report) are:

Year	1957	1958	1959	1960	1961	1962
MW	1,500	1,650	1,850	1,850	2,140	2,294

The 1962 programme, which was adopted during the past year, comprises four new power stations, of which two are steam and two nuclear, and extensions to ten stations that had been started since the war. Planning ahead includes a pilot plant of 3,750 kW capacity, which is being designed for use in connection with the underground gasification of coal at the Newman Spinney site in Derbyshire, and which it is planned to have in service by the end of 1958. Work is being recommenced on the pumped storage scheme at Festiniogg and district-heating experiments are being made at Bromborough, in which steam extracted from the station provides the heat requirements of a neighbouring factory. Preliminary designs are in hand for a group supply scheme at Warrington. The district-heating scheme now in operation at Pimlico has completed its fifth year, and showed heat losses on the distribution system as a whole of 6·4 per cent. The heat sent out was 640 therms to each of the 2,400 flats connected with the scheme.

On the engineering side, plant design now includes a new rating of 275 MW. This is the highest that could be contemplated for operation in 1962 and the design problems were seriously affected by the weight restriction of road transport of 150 tons. It was decided to develop a unit of 275 MW with a single-line turbine, which would be followed by one of 550 MW with a two-line turbine of a cross-compound design. For a comparison, the 550 MW unit proposed for the 1963 programme has a greater electrical output than the whole of the Battersea power station. The use of larger sets, and of the unit system, has so reduced the size of power station required (measured in cubic feet) that the cost per kW installed is the same as in 1948.

The first unit having a liquid-cooled stator winding went into commission at the Bold A power station during the year. This is a small unit, rated at 30 MW, but it is believed to be the first of its type in the world, and the application of liquid-cooled windings has been adopted for the 200 MW generators in West Thurrock and Willington B installations.

The record for the year shows that the increase in generating efficiency has been well maintained. In 1955-56 the average efficiency for all steam stations was 24·35 per cent. In 1956-57 it rose to 24·93 per cent., representing a saving in coal of rather more than a million tons, and a saving in cost of £3·9 million. In the last pre-vesting year (1947-48) the overall efficiency was 20·91 per cent. The present plant includes many stations that have been in service for 25 years, and figures for the 20 best stations are considerably higher: the average is 29·14 per cent., and the highest single station (Castle Donington) has 31·53 per cent. efficiency. It should be noted that this station also has the highest average load, given as a percentage of maximum output capacity, the figure being 92 per cent.

The Authority continues to be the largest individual user of coal in Great Britain and during the year consumed over 41¼ million tons. Another 1½ million tons of other fuels were used. This fuel consumption shows an increase of 4·1 per cent. on the previous year, but the improvement in overall efficiency gave an increase in electricity generated of 5·2 per cent.

It is frequently stated that, for industrialised countries, the consumption of electricity doubles over ten years. The actual increase in Great Britain has been greater than this, for the figures quoted show a 106·7 per cent. increase in electricity purchased by consumers during the nine years since vesting day. The number of consumers for the same period has increased by 35 per cent. Half of the sales went to industry, three-tenths to domestic consumers, and one-eighth to commercial consumers. One particular increase in industry is reported by the North Eastern Board, who say that the demand of the shipbuilding and repair yards has grown markedly. In spite of the increased demand, however, for the first year since the war the Authority met the peak loads without having to resort to reduction of voltage or frequency or to load shedding. This was undoubtedly in part due to a comparatively mild winter, and it is pointed out that there is still no plant to spare should a severe winter be encountered.

The extension of the grid system which now covers 5,500 route miles of overhead lines and underground cable, and of the super-grid system operating at 275 kV, will undoubtedly aid the problem of load distribution during peak demands. Another aid to spreading the load is the proposed cross-Channel submarine cable on which pre-service trials have been carried out during the year.

As one of the largest consumers of fuel, the Authority are naturally concerned with the Clean Air Act, and research is continuously proceeding on combustion, the composition of flue gases and the deposit of dust as influenced by meteorological conditions. To this end, theoretical and experimental studies were made of atmospheric movements, particularly of temperature inversions, and the special survey of dust deposition in the neighbourhood of Little Barford station was concluded.

Another survey undertaken in the narrow valley containing the Llynfi station (near Bridgend) showed that sulphur-dioxide pollution at ground level was small, even on hills higher than the chimney tops, but that the dust deposit was heavier than at Little Barford. Nearly 400 monthly measurements of atmospheric pollution in districts around some 50 power stations were made, and over 300 for sulphur gases. Again, it was shown that the height of the chimneys at the new power stations, and the temperatures and velocities of the gases leaving the chimneys, ensured satisfactory dispersal of the gases into the upper atmosphere. The largest and most modern plants for grit-arresting allow less than 1 per cent. of the dust in the flue gases to escape into the atmosphere.

A waste product from all stations is the ash produced as a result of the combustion of coal: at Battersea power station a sintering plant has been installed for the conversion of the annual output of 65,000 tons of ash into a lightweight

* Annual Report and Accounts for the year ended March 31, 1957, Central Electricity Authority.

aggregate (ENGINEERING, vol. 183, page 721, 1957). The current rate of production of ash from all power stations is at present about 6·7 million tons per year, of which about 3·2 million tons are in the form of fine dust collected from pulverised fuel furnaces. The ash, and particularly the dust, creates a serious and increasing disposal problem. The Authority have continued to support experimental work at the Building Research Station on the conversion of fine ash to a lightweight aggregate and on brickmaking using a fine ash mixed with clay. It is proposed to establish an experimental brickworks at the site of the Hams Hall power station near Birmingham, to demonstrate the practicability of large-scale brick making (initially 5 million bricks of up to 85 per cent. ash content per annum) and to obtain cost data.

Against the background of a recent European survey published by O.E.E.C.,* the report shows the same general trends. Units tend to be increasing in size, and transmission lines in voltage. As regards plant commissioned since 1953 and planned up to 1960, the United Kingdom leads member countries, both in numbers of sets and total capacity; Germany comes second and France third. The United Kingdom and France are the only countries reported as having plans for bringing large nuclear plant into service by 1960-61.

* Survey of Electric Power Equipment, O.E.E.C., 2 Rue André-Pascal, Paris 16.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Work of the National Inspection Council," by E. J. Sutton. South East London Branch. Eltham Green School, Queenscroft-road, Eltham, S.E.9. Tues., Oct. 1, 7.15 p.m.
"Switchgear-Design and Application," by E. Jacks. West London Branch. Windsor Castle Hotel, 134 King-street, Hammersmith, W.6. Tues., Oct. 1, 7.30 p.m.
"Electric Lifts and Equipment," by W. T. Wagon. North London Branch. Queen's Head, 677 Green Lanes, Harrigay, N.4. Wed., Oct. 2, 7.45 p.m.
BATH
Film Evening. Bristol and West of England Branch. Royal York Hotel, Bath. Fri., Oct. 4, 8 p.m.
LIVERPOOL
"Earthing and Its Problems," by P. W. Cave. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Oct. 4, 7.30 p.m.
MANCHESTER
"Railway Electrification," by J. K. Lord. Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., Oct. 2, 7 p.m.
READING
"Space Flight," by Dr. L. R. Sheppard. Oxford, Reading and Districts Branch. Agricultural Hall, 121 Oxford-road, Reading. Tues., Oct. 1, 7.15 p.m.
SOUTHAMPTON
"Some Problems in Sound Production," by F. H. Brittain. Southampton Branch. Polygon Hotel, Southampton. Thurs., Oct. 3, 8 p.m.

Building Centre

LONDON
Film "Out of This Earth," exhibited by Bellrock Gypsum Industries Ltd. Wed., Oct. 2, 12.45 p.m.

Helicopter Association

LONDON
"Tilt Wing Aircraft in Comparison with Other Vtol and Stol Systems," by W. Z. Stepniewski. Royal Aeronautical Society 4 Hamilton-place, London, W.1. Fri., Oct. 4, 6 p.m.

Illuminating Engineering Society

LONDON
Presidential Address on "Designing for Harmony," by E. B. Sawyer. Royal Institution, Albemarle-street, W.1. Tues., Oct. 8, 6 p.m.
EDINBURGH
"Lighting in the Home," by D. P. Bliss and H. Hellier. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Oct. 2, 6.15 p.m.
GLASGOW
"Lighting in the Home," by D. P. Bliss and H. Hellier. Glasgow Centre. Lighting Service Bureau of Scotland, 29 St. Vincent-place, Glasgow, C.1. Thurs., Oct. 3, 6.30 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. Chairman's Address, by R. J. Fothergill. Newcastle-upon-Tyne Centre. King's College, College-road, Newcastle-upon-Tyne, 1. Wed., Oct. 2, 6.15 p.m.

Incorporated Plant Engineers

LONDON
"Reactor Plant Engineering," by R. F. Jackson. General Meeting. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 1, 7 p.m.*
EDINBURGH
"Practical Plant Engineering in the Chemical Industry," by C. W. Winstock. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Oct. 1, 7 p.m.
LEEDS
"The Safe Use of Electricity," by S. J. Emerson. West and East Yorkshire Branch. The University, Leeds. Mon., September 30, 7.30 p.m.
LEICESTER
"Factory Flooring," by Dr. F. C. Harper. Leicester Branch. Bell Hotel, Leicester. Wed., Oct. 2, 7 p.m.
NOTTINGHAM
"The Heat Pump: Some Aspects of Its Application," by J. A. Sumner. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Tues., Oct. 1, 7 p.m.
PETERBOROUGH
"Hydro-Electric Power Development," by G. C. Cummings. Peterborough Branch. White Lion Hotel, Church-street, Peterborough. Tues., Oct. 1, 7.30 p.m.
PORTSMOUTH
"The Engineer and the Clean Air Act," by E. C. Rogers. Southern Branch. Royal Beach Hotel, Portsmouth. Wed., Oct. 2, 7.30 p.m.

Institute of Marine Engineers

LONDON
Presidential Address "Lloyd's Register of Shipping and the Marine Engineer," by Sir Ronald Garrett. Tues., Oct. 1, 5.30 p.m.*
"Recent Developments in British Naval Main Propulsion Steam Turbines," by the late F. J. Cowlin and A. F. Veitch. Tues., Oct. 8, 5.30 p.m.*

Institute of Marine Engineers and Institution of Naval Architects

PORTSMOUTH
"Some Applications of Electronics to Ship Tank Investigations," by S. G. Lankester. Southern Joint Branch. Portsmouth College of Technology, Portsmouth. Tues., Oct. 1, 7.30 p.m.

Institute of Petroleum

LONDON
"Modern Trends in Petroleum Analysis," by Dr. H. Powell and W. H. Thomas; and "New Trends in the Instrumentation of Refinery Processes," by S. W. J. Wallis and D. S. Townend. Wed., Oct. 2, 5.30 p.m.*

Institute of Road Transport Engineers

LONDON
Annual General Meeting. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Oct. 3, 6.30 p.m.*

Institution of Civil Engineers

LONDON
"Investigation of Rainfall, Runoff and Yield on the Alwen Brenig Catchments," by W. K. Lewis. Tues., Oct. 1, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Presidential Address, by T. E. Goldup. Thurs., Oct. 3, 5.30 p.m.*
Chairman's Address "Meters and Meter Engineers," by H. S. Petch. Measurement and Control Section. Tues., Oct. 8. 5.30 p.m.*
BIRMINGHAM
Annual General Meeting and Conversazione. Chairman's Address, by L. I. Tolley. South Midland Centre. Grand Hotel, Birmingham. (Admission by ticket.) Mon., Oct. 7 6 p.m.
LEEDS
Chairman's Address, by A. J. Coveney. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Oct. 1, 6.30 p.m.
LOUGHBOROUGH
Informal Converszione and Reunion. East Midland Centre. Loughborough College, Loughborough. Tues., Oct. 1, 6.30 p.m.*
MANCHESTER
Chairman's Address, by F. R. Perry. North Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Oct. 1, 6.30 p.m.
PORTSMOUTH
Chairman's Address, by Dr. L. G. A. Sims. Southern Centre. Offices of the Southern Electricity Board, Portsmouth. Wed., Oct. 2, 6.30 p.m.

Institution of Engineers-in-Charge

LONDON
Annual General Meeting. Caxton Hall, off Victoria-street, S.W.1. Wed., Oct. 9, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

NEWCASTLE-UPON-TYNE
"Industrial Heating," by P. A. Coles. North-East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Oct. 1, 6.30 p.m.
NOTTINGHAM
Discussion on "Practical Problems of Oil Firing." East Midland Branch. College of Art and Crafts, Waverly-street, Nottingham. Wed., Oct. 2, 6.30 p.m.

Institution of Highway Engineers

LONDON
"Construction of Soil Cement Roads and Road Bases in Holland," by F. A. van der Sluis. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Fri., Oct. 4, 5.30 p.m.
LINCOLN
"Control in the Manufacture and Laying of Bituminous Materials," by H. G. Barnes. Yorkshire and Lincolnshire Branch. Technical College, Lincoln. Thurs., Oct. 3, 7 p.m.
NORWICH
"Ordnance Survey," by Major E. P. J. Williams. East Anglia Branch. Assembly House, Norwich. Tues., Oct. 1, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Annual General Meeting and Chairman's Address. Automobile Division. Tues., Oct. 8, 6 p.m.*
COVENTRY
"Suspension of Internal-Combustion Engines in Vehicles," by M. Horovitz. Coventry A.D. Centre. Leofric Hotel, Coventry. Tues., Oct. 1, 7.30 p.m.
HARWELL
"Patenting an Invention," by C. Lees. Southern Branch. Atomic Energy Research Establishment, Harwell. Wed., Oct. 2, 7 p.m.
MANCHESTER
"Principles and Applications of Hydrodynamic-Type Gas Bearings," by G. W. K. Ford, D. M. Harris and D. Pantall. North Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 3, 6.45 p.m.

Institution of Naval Architects

LONDON
"Some Problems of Yacht Measurement," by D. Phillips-Birt. Thurs., Oct. 10, 4.45 p.m.*

Institution of Production Engineers

BIRMINGHAM
"Developments and Applications of the Manufacture of Fibre Glass," by A. Pimblett. Birmingham Graduate Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Oct. 8, 7 p.m.
CHELMSFORD
"Pride in Workmanship," by Sir Gordon Russell. South Essex Section. Mid-Essex Technical College and School of Art, Chelmsford. Wed., Oct. 2, 7.30 p.m.
COLCHESTER
"Automation: Development of Transfer Equipment," by A. J. Sephton. Ipswich and Colchester Section. Canteen, Britannia Works, Davey, Paxman & Co., Ltd., Colchester. Fri., Oct. 4, 7.30 p.m.
NOTTINGHAM
"Principles and Applications of Pneumatics in Production," by P. X. Kay. Nottingham Section. Victoria Station Hotel, Nottingham. Wed., Oct. 2, 7 p.m.
READING
"Some Aspects of Automation," by A. L. Stuchbery. Reading Section. Great Western Hotel, Reading. Thurs., Oct. 3, 7.30 p.m.

Institution of Works Managers

BIRMINGHAM
"Industrial Relations To-day," by Sir Frederick Leggatt, K.B.E. Birmingham Branch. New College, Birmingham College of Technology, Costa Green, Birmingham. Tues., Oct. 8, 7 p.m.

Junior Institution of Engineers

LONDON
Pictorial record of the meeting in Switzerland and of the summer excursion to Crawley and Penshurst, presented by E. M. Baskerville; and a film display. Fri., Oct. 4, 7 p.m.*
BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed Oct. 2, 7 p.m.

Physical Society

LONDON
"Colour and Steelmaking," by Dr. B. O. Smith. Colour Group. Royal Photographic Society, 16 Princes-gate, South Kensington, S.W.7. Wed., Oct. 9, 3.30 p.m.
OXFORD
Charles Chree Address on "The Ionosphere as Dynamo and Motor," by Dr. D. F. Martyn (of the Commonwealth Scientific and Industrial Research Organisation). Physiology Lecture Theatre, Oxford. Thurs., Oct. 3, 6 p.m.

Plastics Institute

LONDON
"Challenge of Plastics to the Arts and Technology," by Sir Miles Thomas. Fifth Education Conference. Borough Polytechnic, Borough-road, S.E.1. Fri., Oct. 4, 2.30 p.m. President's Reception and Conversazione. Science Museum, Exhibition-road, South Kensington, S.W.7. Fri., Oct. 4, 7.30 for 8 p.m. (Tickets 25s.)

Royal Society of Health

WEYMOUTH
"Public Health Aspects of Atomic Energy," by Dr. Katharine Williams. St. John Hall, Westway-road, Weymouth. Thurs., Oct. 3, 10.30 a.m.

Society of Chemical Industry

LONDON
"The Corrosion Resistance of Titanium," by J. B. Cotton and H. Bradley. Corrosion Group. Wed., Oct. 9, 6.30 p.m.*

Society of Instrument Technology

LONDON
"A System for Handling Wind-Tunnel Data," by J. F. H. Scholes. Data Processing Section. Manson House, 26 Portland-place, W.1. Thurs., Oct. 10, 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Marine Engineers, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Works Managers, 196 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Plastics Institute, 6 Mandeville-place, London, W.1. (WELbeck 5439.)
Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

The Human Element

New Methods Mean New Attitudes

The news last week that there are signs of agreement between the British Transport Commission and the locomotive workers on the manning of Diesels is very welcome. It shines at the moment like a good deed in a naughty industrial world. If a basis of manning these new engines can be satisfactorily worked out without industrial trouble it will be a major success for the railway modernisation programme.

It is, of course, true that time is working on the side of efficient manning for there must be a fairly high wastage rate in engine driving due to retirement. It would be more than a pity, however, if the requirements of steam locomotives were to be written into the recruitment policy of the Diesel age. It is apparent that modernisation is unlikely to remove a great many of the labour relation problems of the railways. These stem not from technical change but from inter-union rivalries and from traditional attitudes which are slow to alter. All the more reason, therefore, why those changes which are coming about from technical developments should be settled early and amicably.

Asking for More

A round of wage demands is lined up for the autumn—relics of those old-fashioned days when Bank rate was at 5 per cent. So far, however, there is no indication that these particular antiques are considered to be such by those who have concocted them. It will indeed be part of the success of the drastic monetary tactics of last week if the trade unions are a little less bold in pressing their demands for higher wages.

The list of claims is a long one. The railwaymen are pressing for a substantial rise and the British Transport Commission is likely to be faced with demands from the clerks as well. The A.E.U. are now pressing for a 40 hour week. The 40 hour week is also called for by the miners (at the surface), the building unions and the shipbuilders. Clothing workers and London busmen have put in wage claims and so have co-operative workers. These demands fall into two groups—those which are a periodic claim after a reasonable run of stable wage rates and the others a seasonal try-on with the unions morally committed to fulfilling certain conditions which have still to be carried out. It is high time that the term " business ethics " was given a wider context than is popular in most quarters.

From the remarks of the Chancellor of the Exchequer last week, when he raised the Bank rate from 5 to 7 per cent., it is clear that he hoped, among other things, to commend wage restraint to the unions. It is doubtful if there will be a direct impact from higher Bank rate on union policy. Exhortation is a weapon, and not a very effectual one, for Socialist governments. The influence is likely to be more indirect through apprehension about lower profit margins and a small degree of unemployment. It is already apparent that union leaders are on the lookout for unemployment resulting from last week's monetary adjustment. Some of the wage demands now about to be considered will go through their preliminary stages before the effect of a higher Bank rate can work themselves out. But there is a hope, and it is no stronger than that, for Bank rate at 7 per cent. to induce a mood of cautious sobriety.

Payment for Personality

The recent proposals for drastically reforming the basis of remuneration for professional footballers has something more to it than Saturday afternoon recreation or the Cup Final at Wembley. There is a point of substance for employers and workers alike in all branches of British industry. It is a warning that whatever either side may try to do about it, the market will assert its influence in the end. At times of high employment and a sellers' market such thoughts are acceptable enough to organised labour but it may not always be so. In the end, however, the market price will win. The alternative is some form of " fiddling "—respectable or otherwise.

The economics of professional football are complicated. Turnover is large but profits on the average are small. Many clubs sustain their traditional national position (won in days when costs rose with less relentless inevitability than nowadays) by stringent economies and by wealthy directors frequently putting their hands into their pockets. In one sense the multi-league system of the big teams is an alternative to what in other industries is called success and bankruptcy. But the system is run largely on the pulling power of personalities and in the end they will get the price of that pulling power. No-one has ever suggested—with any hope of attaining his view—that film stars should get only a skilled workman's wage when the film industry is depressed.

Call for Work Study

Since 1953 about 1,000 students have passed through the work study school of the Engineering and Allied Employers' West of England Association and more facilities are planned. Schemes of this size even on a regional basis demonstrate the large amount of industrial energy which goes into the calculation of improved piece rates, especially in the engineering industry. The annual conference of the work study department this year chose as its theme the value of method study at the design and drawing board stage of a project.

There is an influential school of thought to-day which would prefer to see high time rates in industry (quoting American experience) rather than an extension of bonus incentive schemes based on motion study. The fact is that the element of time and motion in work study is beginning to be assessed against a broader background—to its advantage. There is still too much crude rate fixing in industry but it is passing. It is to be hoped that the current fashion in work study does not go too far and the other point of view gain an equally uncritical following. There are arguments both for good method study (often taking within it time and motion study) and also for the exclusion of piece rate or bonus incentive work altogether. Probably the best position lies at neither extreme.

Business on Wheels

A recent decision of the British Transport Commission to provide secretarial services on some of their trains underlines the modern tendency in the world of affairs toward sustained breathlessness.

Time has never been at so high a premium and relaxation or the day-time snooze at one so low. Instead of reading an assortment of periodicals and maybe a thriller or two in a four to six hour journey to the North, and probably dozing off by the time he gets to Crewe, today's traveller will feel compelled to ring for a secretary and dictate furiously all the time. If the accommodation provided matches the secretarial service there need be no break at all in the day's work but for the brief journey to the station. But even this can now be gainfully occupied issuing instructions to staff, holding the last meeting of the day or simply dashing off various letters that can't wait for the morning post.

Rolls-Royce are introducing a car " to meet the present day needs of the busy executive." It is a Silver Cloud with a long wheel-base to give room for a division between front and rear seats. At the touch of a button the business man can isolate himself and " make notes, carry on a private discussion or simply relax." It is good to note the last two words: Rolls-Royce have not yet lost their sense of proportion. Business on wheels is fine, but can the modern business man really cram into his life so much more than his forebears? It is difficult not to conclude that so intense and busy an existence also means a brief one.

Customers' Cut

Co-operative retail stores sold £63·5 million more goods in 1956 than in the previous year, an advance of 7·7 per cent. to £886 million. This is more than that of any other type of shop. A surplus of £62 million was earned on the year's trading. These results were obtained during a period of all-round expansion, which included wholesale societies as well as those concerned with insurance and housing. The facts and figures quoted in the annual report of the Chief Registrar of Friendly Societies, Sir Cecil Crabbe, show that in sheer size and rate of growth there is little wrong with the co-operative movement.

That there should have been considerable growth since the war is not difficult to explain: all retail outlets, and the large organisations in particular, have expanded considerably in parallel with the growth in consumer demand. That the Co-op. should gain materially at the expense of the multiples such as Woolworths or Marks and Spencer, or at that of the department stores, is more surprising. The " divvy " has doubtless played an important part: last year £55 million of the year's £62 million surplus was paid out. Dividends on sales averaged 1s. 1d. in the £ and 2·75 per cent. was paid out on investment shares. Membership increased by 297,000 to 11·9 million, and share capital from £240 million to £245·1 million.

This is big business indeed and there is no doubt that it meets the needs of the housewife. Yet the Co-op.'s methods of distribution do not impress. The growth of supermarkets and retail chains with capital to invest in modern methods is there for all to see and may yet challenge the Co-operative Societies' ascendency unless something is done quickly to fall in step.

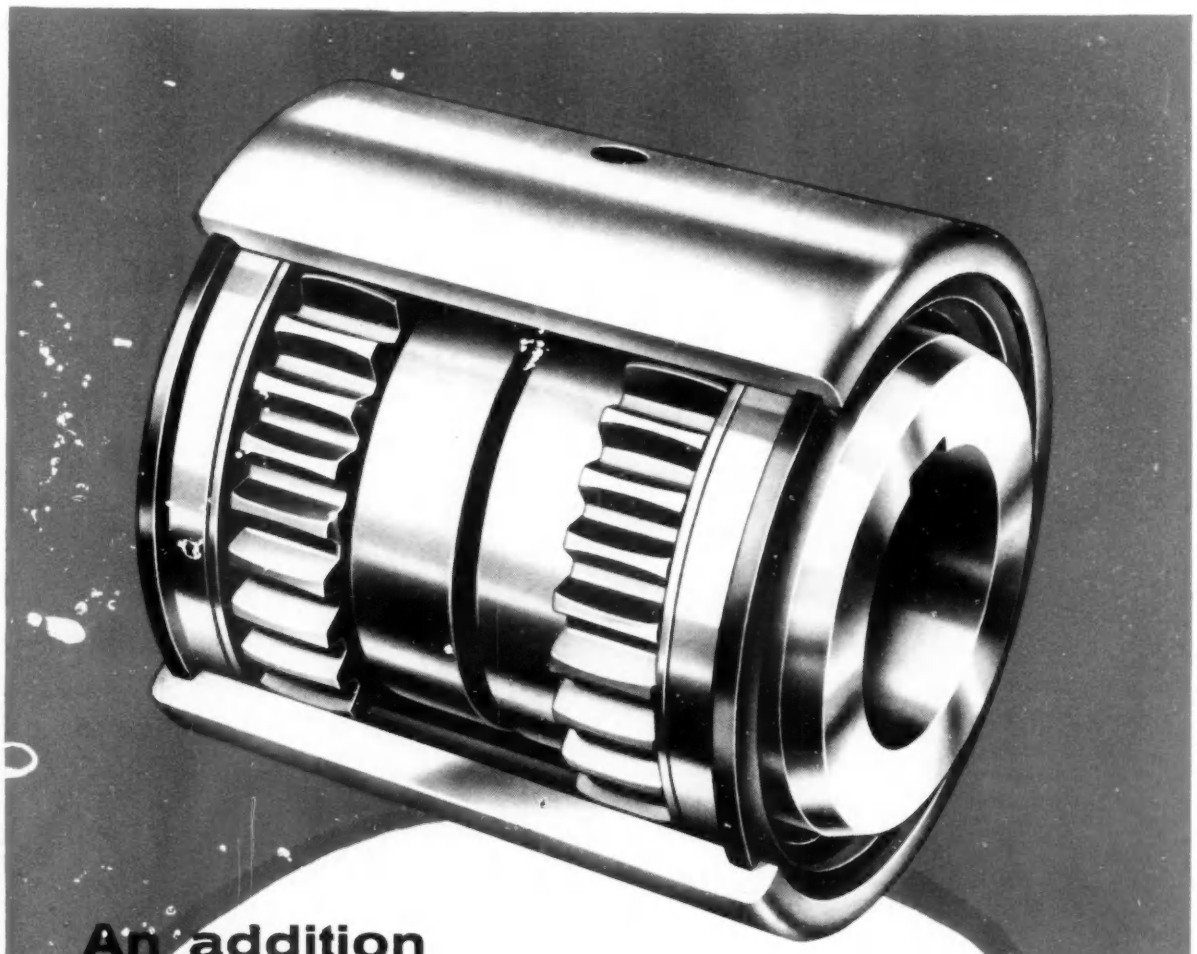
Avant-Garde

The exhibition of paintings by two chimpanzees last week at the Institute of Contemporary Arts Gallery in London has been the object of gentle banter in the Press, a gesture which has been followed by a somewhat unnecessary outbreak of lack of humour by those who should know better. To the lay public, the mood of the reception of such an exhibition is more important than the exhibition itself. To most people it seems reasonable that if men and monkeys have common ancestors then monkey daubs might be expected to present a faintly recognisable art-form to the human eye and intellect.

A century ago such an exhibition would have created a sensation as further proof of the evolution of the species. To-day the theory is considered accepted or hardly relevant. The mood of the world is less to be stirred by thoughts of where the human species came from as to where it is going to by way of guided missile and the atomic warhead. For those who are engaged in the minutiæ of research into human origins on this planet, the antics of monkeys are of absorbing interest. If their specimens are offered to public view they must put up with an amused and indifferent tolerance. After all, monkeys presumably have a sense of humour. If they have not, the evolutionists had better invent one for them pretty quickly, for it is of more importance to the human species to-day than either their appendices or their paintings.

ENGINEERING

An Illustrated Weekly Journal



An addition to the Moss Gear range...

TUBULAR GEARED SLEEVED COUPLING

Yet a further addition to the Moss Gear range of couplings is the Tubular Geared Sleeved Coupling. Simplicity of design, together with the fullest possible economy, make this latest Moss Gear Coupling ideal where sufficient room for alignment is available.

Full details and specifications will be gladly sent upon request.

MOSS GEARS

THE MOSS GEAR CO. LTD · CROWN WORKS · TYBURN · BIRMINGHAM 24

Telephone: ERDington 1661-6 Telegrams: "Mosgear", Birmingham.